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PUBLIC UTILITIES
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The Honorable Chair and Members of the
Hawai'i Public Utilities Commission
Kekuanaoa Building
465 South King Street, First Floor
Honolulu, Hawai'i 96813

Dear Commissioners:

Subject: Hawaiian Electric Companies Annual Service Reliability Reports for 2016

Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited respectfully submit a copy of its Annual Service Reliability Report for the year 2016. (See Attachments 1, 2, and 3, respectively.)

Sincerely,

Daniel G. Brown
Manager, Regulatory Non-Rate Proceedings

Attachments

c: Division of Consumer Advocacy (with Attachments)

HAWAIIAN ELECTRIC COMPANY, INC.
ANNUAL SERVICE RELIABILITY REPORT
2016

Prepared by
System Operation Department

April 25, 2017

INTRODUCTION

This is the 2016 annual service reliability report of the Hawaiian Electric Company. The year-end average number of electric customers increased from 302,499 in 2015 to 303,732 in 2016 (a 0.41% increase). The 2016 peak demand for the system was 1,229 MW gross on the evening of August 24, 2016, 17 MW lower than the peak demand in 2015; the highest system peak demand remains at 1,327 MW gross set on the evening of October 12, 2004.

The system interruption summary for 2016 (Attachments A and B) and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer. Attachment C contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (Average Service Availability Index or ASAI), the frequency or number of times Hawaiian Electric Company's customers experience an outage during the year (System Average Interruption Frequency Index or SAIFI), the average length of time an interrupted customer is out of power (Customer Average Interruption Duration Index or CAIDI), and the average length of time Hawaiian Electric Company's customers are out of power during the year (System Average Interruption Duration Index or SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on Hawaiian Electric Company's total customer base (in this case 303,732 customers).

ANALYSIS

This analysis of the annual system reliability for Hawaiian Electric Company is for the year 2016. To determine the relative level of reliability, the statistics for five prior years, 2011 through 2015, are used for comparison.

The reliability indices are calculated using the data from all sustained¹ system outages except customer maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990.² The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

¹An electrical service interruption of more than one minute. (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

² 2016 Annual Service Reliability report prepared using 1990 Methodology for consistency with 2016 quarterly filings to Hawaii Public Utilities Commission. Beginning with 2017, reliability reports will be prepared using IEEE 1366 methodology.

2016 RESULTS

Annual Service Reliability Indices

The reliability results for 2016 and five prior years are shown below in Table 1: Annual Service Reliability Indices – All Events and Table 2: Annual Service Reliability Indices – with Normalization. Tables 3-8 break out the events into three groups; Transmission and Distribution, Generation – Hawaiian Electric, and Generation – Other [non-utility] for all events and then with normalization. One outage event was normalized in 2016 related to flooding from passing tropical storm Darby in July. All subsequent graphic comparisons and discussion are based on only the All Events normalized data from Table 2.

Table 1: Annual Service Reliability Indices - All Events

	2011	2012	2013	2014	2015	2016
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	502,253	407,197	409,516	447,048	642,380	461,553
Customer-Hours Interrupted	1,257,349.4	563,806.5	605,965	541,434.6	770,215.47	556,545.12
SAIDI (Minutes)	254.28	113.67	121.63	108.03	152.77	109.94
CAIDI (Minutes)	150.21	83.08	88.78	72.67	71.94	72.35
SAIFI (Occurrences)	1.693	1.368	1.370	1.487	2.124	1.520
ASAI (Percent)	99.952%	99.978%	99.977%	99.979%	99.971%	99.979%

Table 2: Annual Service Reliability Indices - with Normalization

	2011*	2012	2013	2014	2015	2016*
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	408,327	407,197	409,516	447,048	642,380	459,079
Customer-Hours Interrupted	1,044,915.7	563,806.5	605,965	541,434.6	770,215.47	539,372.92
SAIDI (Minutes)	211.32	113.67	121.63	108.03	152.77	106.55
CAIDI (Minutes)	153.54	83.08	88.78	72.67	71.94	70.49
SAIFI (Occurrences)	1.376	1.368	1.370	1.487	2.124	1.511
ASAI (Percent)	99.960%	99.978%	99.977%	99.979%	99.971%	99.980%

NOTE:

2011* Data normalized to exclude the 03/04/11 Labor Work Stoppage
 Data normalized to exclude the 05/02/11 – 05/03/11 Lightning Storm
 2016* Data normalized to exclude the 07/24/16 Flooding to Iwilei Substation and surrounding area.

Table 3: Transmission & Distribution Events

	2011	2012	2013	2014	2015	2016
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	477,798	341,118	341,930	382,867	459,546	360,871
Customer-Hours Interrupted	1,238,615.1	524,554	576,305.6	524,146.1	723,679.42	508,400.88
SAIDI (Minutes)	250.50	105.76	115.68	104.58	143.54	100.43
CAIDI (Minutes)	155.54	92.26	101.13	82.14	94.49	84.53
SAIFI (Occurrences)	1.610	1.146	1.144	1.273	1.519	1.188
ASAI (Percent)	99.952%	99.980%	99.978%	99.980%	99.973%	99.981%

Table 4: Generation Events – Hawaiian Electric

	2011	2012	2013	2014	2015	2016
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	24,455	0	0	0	26,914	73,912
Customer-Hours Interrupted	18,734.3	0	0	0	18,772.23	47,033.88
SAIDI (Minutes)	3.79	0.00	0.00	0.00	3.72	9.29
CAIDI (Minutes)	45.96	0.00	0.00	0.00	41.85	38.18
SAIFI (Occurrences)	0.082	0.000	0.000	0.000	0.089	0.243
ASAI (Percent)	99.999%	100.000%	100.000%	100.000%	99.999%	99.998%

Table 5: Generation Events – Other [non-utility]

	2011	2012	2013	2014	2015	2016
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	0	66,079	67,586	64,181	155,920	26,770
Customer-Hours Interrupted	0	39,252.5	29,659.4	17,288.5	27,763.82	1,110.35
SAIDI (Minutes)	0.00	7.91	5.95	3.45	5.51	0.22
CAIDI (Minutes)	0.00	35.64	26.33	16.16	10.68	2.49
SAIFI (Occurrences)	0.000	0.222	0.226	0.213	0.515	0.088
ASAI (Percent)	100.000%	99.998%	99.999%	99.999%	99.999%	100.000%

Table 6: Transmission & Distribution Events with Normalization

	2011*	2012	2013	2014	2015	2016*
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	383,872	341,118	341,930	382,867	459,546	358,397
Customer-Hours Interrupted	1,026,181.4	524,554	576,305.6	524,146.1	723,679.42	491,228.69
SAIDI (Minutes)	207.53	105.76	115.68	104.58	143.54	97.04
CAIDI (Minutes)	160.39	92.26	101.13	82.14	94.49	82.24
SAIFI (Occurrences)	1.294	1.146	1.144	1.273	1.519	1.180
ASAI (Percent)	99.961%	99.980%	99.978%	99.980%	99.973%	99.982%

Table 7: Generation Events – Hawaiian Electric with Normalization

	2011	2012	2013	2014	2015	2016*
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	24,455	0	0	0	26,914	73,912
Customer-Hours Interrupted	18,734.3	0	0	0	18,772.23	47,033.88
SAIDI (Minutes)	3.79	0.00	0.00	0.00	3.72	9.29
CAIDI (Minutes)	45.96	0.00	0.00	0.00	41.85	38.18
SAIFI (Occurrences)	0.082	0.000	0.000	0.000	0.089	0.243
ASAI (Percent)	99.999%	100.000%	100.000%	100.000%	99.999%	99.998%

Table 8: Generation Events – Other [non-utility] with Normalization

	2011	2012	2013	2014	2015	2016*
Number of Customers	296,679	297,598	298,920	300,722	302,499	303,732
Customer Interruptions	0	66,079	67,586	64,181	155,920	26,770
Customer-Hours Interrupted	0	39,252.5	29,659.4	17,288.5	27,763.82	1,110.35
SAIDI (Minutes)	0.00	7.91	5.95	3.45	5.51	0.22
CAIDI (Minutes)	0.00	35.64	26.33	16.16	10.68	2.49
SAIFI (Occurrences)	0.000	0.222	0.226	0.213	0.515	0.088
ASAI (Percent)	100.000%	99.998%	99.999%	99.999%	99.999%	100.000%

Figure 1: Customer Average Interruption Duration Index (CAIDI)

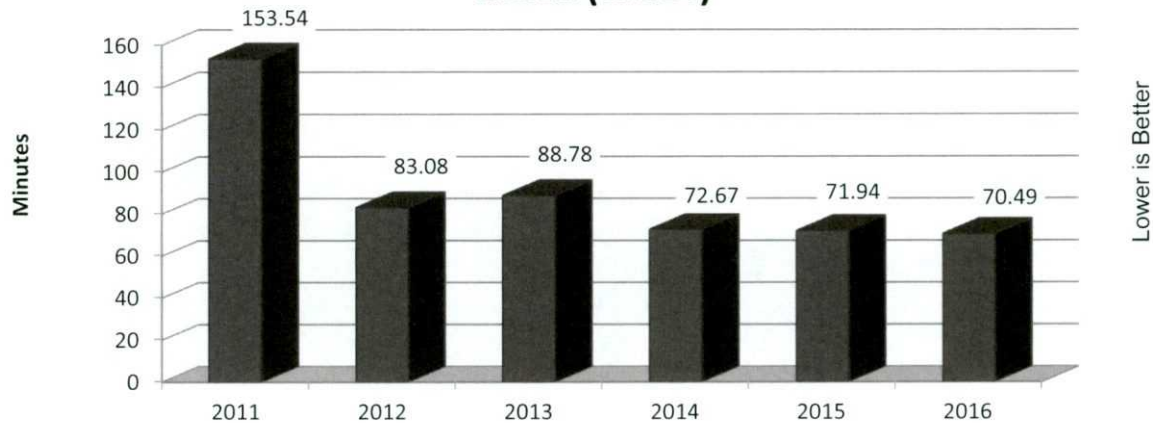


Figure 1 shows the Customer Average Interruption Duration Indices (CAIDI) for the past six years. The 2016 CAIDI of 70.49 minutes, is a 2% decrease compared to the 2015 CAIDI, making it the best CAIDI result in the last six years.

Continued performance improvement and noticeable downward trend is a result of our increasing grid modernization initiatives. DA (distribution automation) and SCADA (supervisory control and data acquisition) apparatuses are strategically placed smart grid devices to aide in circuit fault detection which enables quicker isolation of the problem resulting in quicker power restoration. Fundamentally, the grid modernization provides immediate alarms to the System Operation Control Center (SOCC), enabling and alerting the SOCC personnel to assess and respond to deploy field crews effectively and efficiently, and allowing more remote controllability to restore customers as well.

Three major events impacting the 2016 CAIDI results were:

1. October 4, 2016 (Tuesday) – A Switching Error overloaded a 46kV conductor causing it to sag and contact the underbuilt 12kV lines in Makaha affecting 5,517 customers causing a sustained interruption from 2 hours and 51 minutes for some or up to 2 hours and 56 minutes for others. This incident added 1.25 minutes to the annual 2016 CAIDI. This event was reported on the October monthly PUC report having lost greater than 1% of peak load. Later that same night, the same Switching Error again overloaded a 46kV conductor causing it to sag and contact the underbuilt 12kV lines in Makaha affecting 5,517 customers causing a sustained interruption from 3 hours and 7 minutes for some or lasting up to 3 hours and 24 minutes for others. This incident added 1.89 minutes to the annual 2016 CAIDI. This event was reported on the October monthly PUC report having lost greater than 1% of peak load. Combined these two interruptions of service contributed 2.80 minutes to the 2016 CAIDI.

2. November 17, 2016 (Thursday) – A Motor Vehicle Accident near Kaiser High School in Hawaii Kai affected 2,780 customers with some customers experiencing a momentary interruption of service to sustained interruption of 12 hours and 15 minutes for others. This event added 1.51 minutes to the annual 2016 CAIDI.
3. April 28, 2016 (Thursday) – A Scheduled Maintenance outage for Waialae iki in Aina Haina affecting 327 customers causing a sustained interruption from 11 hours and 55 minutes for some or up to 14 hours and 57 minutes for others. This incident added 0.54 minutes to the annual 2016 CAIDI.

Figure 2: System Average Interruption Frequency Index (SAIFI)

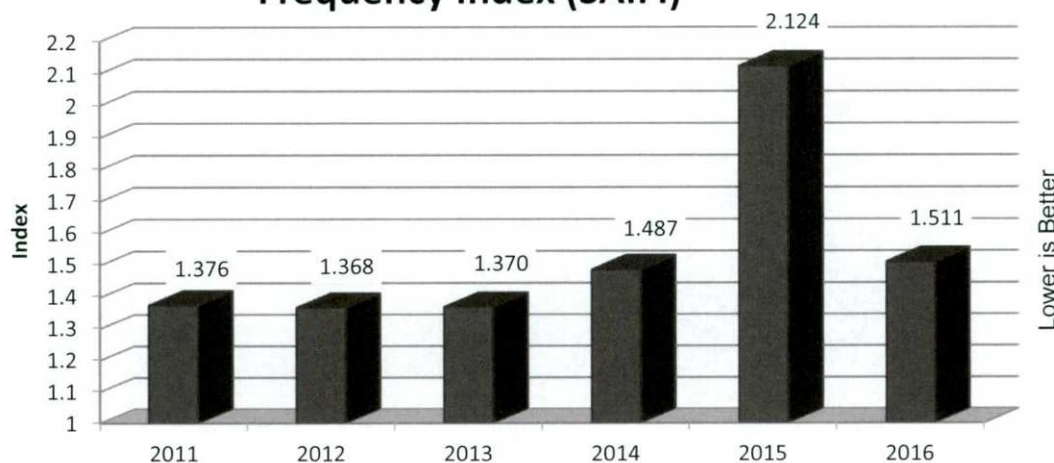


Figure 2 illustrates the System Average Interruption Frequency Index (SAIFI) for the past six years. The 2016 SAIFI of 1.511 had the second most customer interruption occurrences of the past six years, yet still a significant decrease of 27% from the 2015 SAIFI of 2.124. The total number of customer interruptions in 2016 was 459,079 compared to 642,380 interruptions in 2015.

In 2016, there were five events that resulted in the interruption of service to more than 15,000 customers:

1. March 25, 2016 (Friday), Oahu experienced an under frequency load shedding (UFLS) event due to a lightning storm in Ewa Oahu causing the loss of three generators at the Kahe Power Plant and one generator at the H- Power Plant. This event caused a series of interruptions to 68,448 customers or 23% of our customers with interruption of service durations ranging from a momentary interruption to 1 hours and 38 minutes.
2. October 10, 2016 (Monday), Oahu experienced an under frequency load shedding (UFLS) event due to the loss of the island's largest generating unit at the AES facility. This event caused a series of interruptions to 27,584 customers or 9% of our customers with interruption of service durations ranging from a momentary interruption to 5 minutes.
3. July 24, 2016 (Sunday), Oahu was experiencing the effects of passing Tropical Storm Darby, from which there was heavy rains and lightning across the island. While there were many outages this particular day, one event affected 24,849 customers or 8% of our customers with interruption of service durations from a momentary interruption to 3 minutes. This event was normalized out of the 2016 indices.

4. November 17, 2016 (Thursday), an Equipment failure on the sub-transmission level contacted two underbuilt distribution circuits causing interruption to 18,060 customers or 5.95% of our customers with interruption of service durations ranging from a momentary interruption to 3 hours and 58 minutes.
5. July 1, 2016 (Friday), as a result of vandalism in Keolu Substation, 17,729 customers or 5.84% of our customers experienced interruption of service durations ranging from a momentary interruption to 17 minutes.

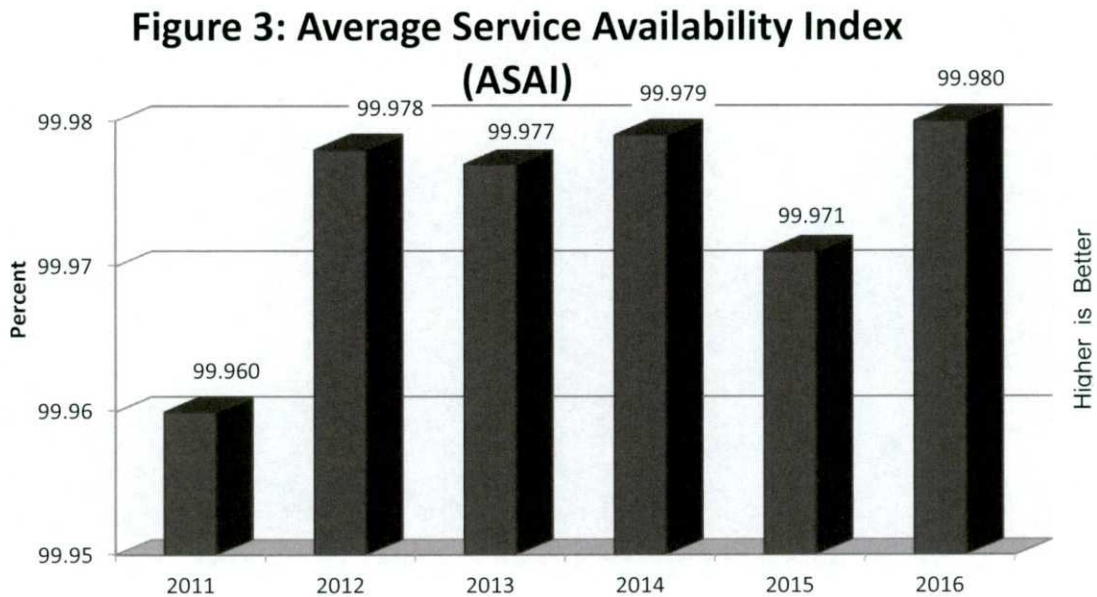


Figure 3 shows that the 2016 Average Service Availability is the highest in the last six years, higher is better, increasing .009% from 2015. With a customer base increase of 1,233 over 2015, the difference of availability equates to approximately 36 more hours of availability per customer for 2016. 2016 ranked the best ASAI performance in the last six years

Figure 4: System Average Interruption Duration Index (SAIDI)

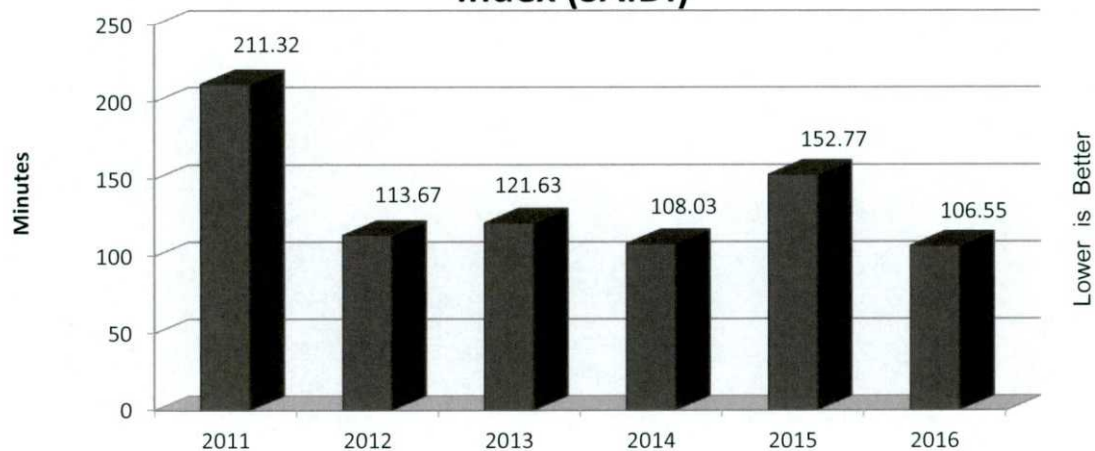
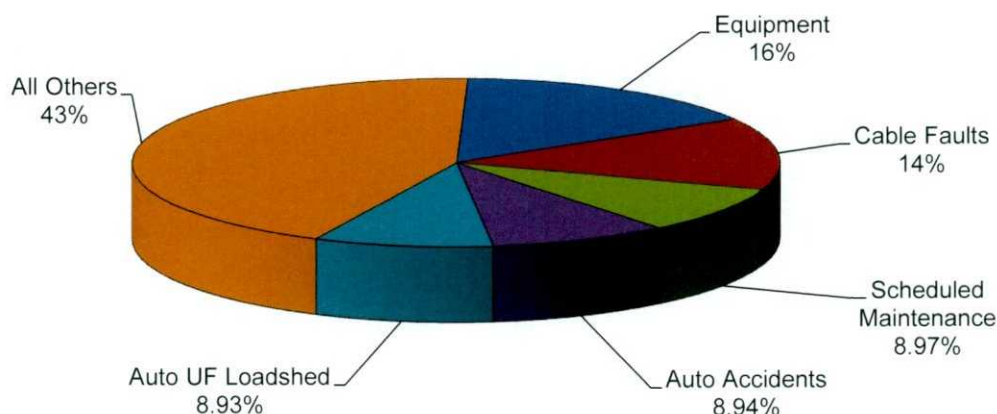


Figure 4 shows the System Average Interruption Duration Indices (SAIDI) for the past six years. The 2016 SAIDI is 106.55 minutes, a 30% decrease compared to the 2015 SAIDI, and resulted in the best SAIDI performance in the last six years. SAIDI improvement is due to excellent restoration times also reflected in CAIDI. The SAIDI is the composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time. Following discussion on outage causes (figure 5.1) and outage types (figures 5.2.1 and 5.2.2) are ranked by SAIDI and compared by the SAID.

Figure 5.1: Outage Top Cause Codes

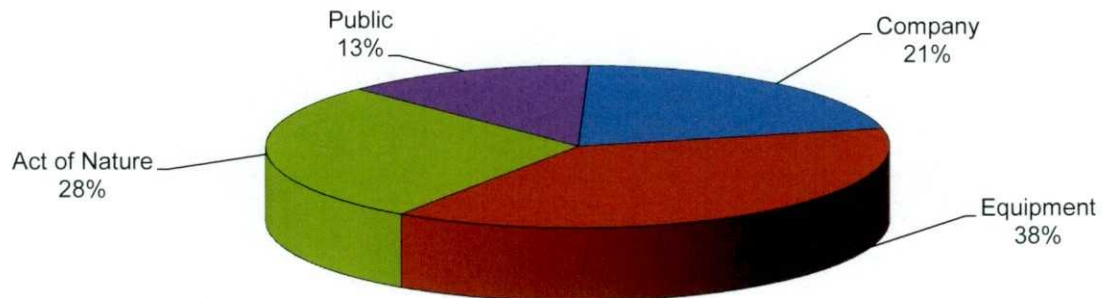


The Top 5 Outage Categories, by SAIDI, these top outage causes are:

<u>Outage Cause Code</u>		<u>Sample Causes</u>
1.	Equipment Deterioration	Failed, broken, corroded equipment
2.	Cable Faults	Underground conductor failure
3.	Scheduled Maintenance	Planned maintenance
4.	Auto Accidents	Outage due to a vehicle collision
5.	Auto UF Loadshed	Deliberate interruptions to prevent failure of entire grid due to inadequate generation for demand.

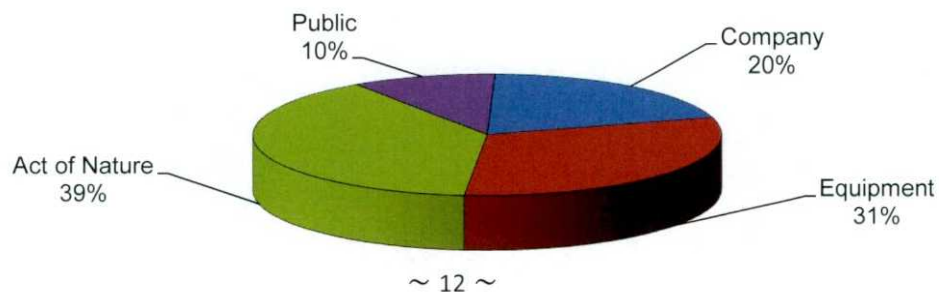
The 2016 top five major causes accounted for 57% of the 2016 total customer hours of interruption; down compared to the 2015 top five major causes making up 72% of the 2015 total customer hours of interruption. The top five major cause factors for 2016 mostly remained the same with 2015 with the exception of High Winds was first, now seventh, and Trees/Branches was third, now eighth. Both cause codes having a significant decrease of customer hours of interruption, High Winds dropping 86% and Trees/Branches dropping 68% from 2016 to 2015. Equipment Deterioration is now ranked first, up from second in 2015, even with a 21% decrease in customer hours of interruption from 108,233.28 in 2015 to 85,845.70 in 2016. Cable faults are now ranked second, up from fourth in 2015, even with a 13% decrease in customer hours of interruption from 85,489.52 in 2015 to 74,524.22 in 2016. Scheduled Maintenance moved from fifth up to third despite a 5% decrease in customer hours of interruption of 50,684.22 in 2015 to 48,380.37 in 2016. Auto Accidents moved up from sixth in 2015 to fourth in 2016 with a 51% increase in customer hours of interruption from 31,957.57 in 2015 to 48,233.75 in 2016. Lastly, Auto UF (Under Frequency) Loadshed moved from eighth up to fifth in 2016 with a 74% increase in customer hours of interruption from 27,754.75 in 2015 to 48,144.23 in 2016.

Figure 5.2.1: Outage Types 2016



All 2016 Outage Types are illustrated in Figure 5.2.1, further shows the combined affect the Equipment failures had on the system as compared with the 2015 outage types in Figure 5.2.2. While failures of Hawaiian Electric equipment has a bigger percentage of the total customer hours of interruption, up 7%, the actual customer hours of interruption due to Equipment type decreased 14% from 152,534.10 in 2015 to 115,809.67 in 2016. Interruptions confined with the Hawaiian Electric system not due to equipment failures percentage of total increased 1%, the actual customer hours of interruption for Company type decreased 24% from 152,534.10 in 2015 to 115,809.67 in 2016. Act of Nature type decreased 11% of total while also seeing a decrease in customer hours of interruption of 51% from 304,705.70 in 2015 to 149,958.40 in 2016. Public type increased 3% of the total while stilling having a decrease in customer hours of interruption from 75,858.20 in 2015 to 68,614.22 in 2016.

Figure 5.2.2: Outage Types 2015



Attachment A

Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2016

To: December 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
EQUIP DETERIORATION	85,845.70	56,790	0.187	16.96	90.70
CABLE FAULT	74,524.22	55,597	0.183	14.72	80.43
SCHEDULED MAINTENANCE	48,380.37	11,557	0.038	9.56	251.17
AUTO ACCIDENT	48,233.75	21,670	0.071	9.53	133.55
AUTO UF LOADSHED	48,144.23	100,682	0.331	9.51	28.69
SYSTEM LOAD MAINTENANCE	31,090.10	28,501	0.094	6.14	65.45
HIGH WINDS	30,241.98	15,084	0.050	5.97	120.29
TREES/BRANCHES IN LINES	29,754.72	22,642	0.075	5.88	78.85
FORCED MAINTENANCE	23,583.98	25,560	0.084	4.66	55.36
UNKNOWN	22,801.62	18,610	0.061	4.50	73.51
COMPANY SWITCHING ERROR	19,031.18	27,136	0.089	3.76	42.08
OVERGROWN VEGETATION	18,329.93	17,504	0.058	3.62	62.83
LIGHTNING	11,895.67	6,896	0.023	2.35	103.50
FLASHOVER	9,037.77	6,542	0.022	1.79	82.89
FAULTY EQUIP OPERATION	7,893.68	12,637	0.042	1.56	37.48
TRANSFORMER FAILURE	5,166.55	802	0.003	1.02	386.52
MYLAR BALLOON	4,932.87	7,053	0.023	0.97	41.96
CONSTRUCTION ACCIDENT	4,576.92	2,654	0.009	0.90	103.47
ANIMAL IN LINES	4,299.80	3,870	0.013	0.85	66.66
CUSTOMER EQUIP	2,382.80	1,777	0.006	0.47	80.45
FIRE	2,002.12	870	0.003	0.40	138.08
VANDALISM	1,820.53	6,651	0.022	0.36	16.42
CONTAMINATION FLASHOVER	1,048.92	1,109	0.004	0.21	56.75
OTHER	959.88	2,139	0.007	0.19	26.93
FOREIGN OBJECT IN LINES	750.95	457	0.002	0.15	98.59
COMPANY PERSONNEL ERROR	743.57	3,157	0.010	0.15	14.13
TRANSFORM OVERLOAD	739.05	381	0.001	0.15	116.39
EQUIP ROT OR TERMITES	610.50	222	0.001	0.12	165.00
EQUIP OVERLOAD	404.07	201	0.001	0.08	120.62
MOVING EQUIP ACCIDENT	141.50	88	0.000	0.03	96.48
TRANSFER LOAD MAINTENANCE	4.00	240	0.001	0.00	1.00
MANUFACTURER EQUIP DEFECT	0.00	0	0.000	0.00	0.00
IPP EQUIP FAILURE	0.00	0	0.000	0.00	0.00
LANDSLIDE/FLOODING	0.00	0	0.000	0.00	0.00
OTHER-GENERATION	0.00	0	0.000	0.00	0.00
CUSTOMER MAINTENANCE	0.00	0	0.000	0.00	0.00
MAN IN LINES	0.00	0	0.000	0.00	0.00
SWITCH LOAD MAINTENANCE	0.00	0	0.000	0.00	0.00
MANUAL UF LOADSHED	0.00	0	0.000	0.00	0.00
NATURAL DISASTER	0.00	0	0.000	0.00	0.00

Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2016

To: December 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
Total	539,372.92	459,079	1.511	106.55	70.49
AVERAGE SYSTEM AVAILABILITY =			99.980%		
NUMBER OF CUSTOMERS FOR THE PERIOD =			303,732		
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 =			129.57		
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 =			303,115		

SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX

SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: Outage causes are listed in order of SAIFI.

Outages with zero customer hours or due to customer maintenance are not included in the report.

Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2016

To: December 31, 2016

Outage Cause	<u>Interruptions</u>		<u>Customer Hours</u>	
	Number	% of Total	Number	% of Total
<u>ACCIDENT</u>	55	2.24	52,952.17	9.82
MOVING EQUIP ACCIDENT	2	0.08	141.50	0.03
CONSTRUCTION ACCIDENT	17	0.69	4,576.92	0.85
AUTO ACCIDENT	36	1.47	48,233.75	8.94
<u>CABLE FAULT</u>	486	19.78	74,524.22	13.82
CABLE FAULT	486	19.78	74,524.22	13.82
<u>COMPANY ERROR</u>	44	1.79	19,774.75	3.67
COMPANY PERSONNEL ERROR	17	0.69	743.57	0.14
COMPANY SWITCHING ERROR	27	1.10	19,031.18	3.53
<u>EQUIPMENT</u>	316	12.86	97,136.75	18.01
EQUIP OVERLOAD	4	0.16	404.07	0.07
MANUFACTURER EQUIP DEFECT	0	0.00	0.00	0.00
IPP EQUIP FAILURE	0	0.00	0.00	0.00
FAULTY EQUIP OPERATION	10	0.41	7,893.68	1.46
EQUIP DETERIORATION	273	11.11	85,845.70	15.92
CUSTOMER EQUIP	28	1.14	2,382.80	0.44
EQUIP ROT OR TERMITES	1	0.04	610.50	0.11
<u>FIRE</u>	2	0.08	2,002.12	0.37
FIRE	2	0.08	2,002.12	0.37
<u>FLASHOVER</u>	14	0.57	10,086.68	1.87
CONTAMINATION FLASHOVER	2	0.08	1,048.92	0.19
FLASHOVER	12	0.49	9,037.77	1.68
<u>GENERATION</u>	77	3.13	48,144.23	8.93
MANUAL UF LOADSHED	0	0.00	0.00	0.00
AUTO UF LOADSHED	77	3.13	48,144.23	8.93
OTHER-GENERATION	0	0.00	0.00	0.00
<u>MAINTENANCE</u>	979	39.85	103,058.45	19.11
SYSTEM LOAD MAINTENANCE	39	1.59	31,090.10	5.76
TRANSFER LOAD MAINTENANCE	2	0.08	4.00	0.00
SWITCH LOAD MAINTENANCE	0	0.00	0.00	0.00
SCHEDULED MAINTENANCE	751	30.57	48,380.37	8.97
FORCED MAINTENANCE	187	7.61	23,583.98	4.37
CUSTOMER MAINTENANCE	0	0.00	0.00	0.00

Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2016

To: December 31, 2016

Outage Cause	<u>Interruptions</u>		<u>Customer Hours</u>	
	Number	% of Total	Number	% of Total
<u>OBJECT IN LINES OR EQUIP</u>	55	2.24	9,983.62	1.85
ANIMAL IN LINES	37	1.51	4,299.80	0.80
FOREIGN OBJECT IN LINES	4	0.16	750.95	0.14
MYLAR BALLOON	14	0.57	4,932.87	0.91
MAN IN LINES	0	0.00	0.00	0.00
<u>OTHER</u>	5	0.20	959.88	0.18
OTHER	5	0.20	959.88	0.18
<u>TRANSFORMER</u>	100	4.07	5,905.60	1.09
TRANSFORMER FAILURE	73	2.97	5,166.55	0.96
TRANSFORM OVERLOAD	27	1.10	739.05	0.14
<u>UNKNOWN</u>	118	4.80	22,801.62	4.23
UNKNOWN	118	4.80	22,801.62	4.23
<u>VANDALISM</u>	2	0.08	1,820.53	0.34
VANDALISM	2	0.08	1,820.53	0.34
<u>VEGETATION</u>	109	4.44	48,084.65	8.91
TREES/BRANCHES IN LINES	78	3.17	29,754.72	5.52
OVERGROWN VEGETATION	31	1.26	18,329.93	3.40
<u>WEATHER</u>	95	3.87	42,137.65	7.81
HIGH WINDS	31	1.26	30,241.98	5.61
LANDSLIDE/FLOODING	0	0.00	0.00	0.00
NATURAL DISASTER	0	0.00	0.00	0.00
LIGHTNING	64	2.60	11,895.67	2.21
Total:	2,457		539,372.92	

NOTES: Outages with zero customer hours or due to customer maintenance are not included in the report.

DEFINITION OF TERMS

OUTAGE

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

INTERRUPTION

The loss of service to one or more consumers and is a result of one or more component outages.

INTERRUPTION DURATION

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

MOMENTARY INTERRUPTION

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HECO Utilities" indicated that momentary interruptions will have a duration of less than one minute.

SUSTAINED INTERRUPTION

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990, a sustained interruption has a duration of one minute or longer.

CUSTOMER INTERRUPTION

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., customer maintenance) are not considered.

RELIABILITY INDICES

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Four reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

AVERAGE SERVICE AVAILABILITY INDEX (ASAI)

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$

HAWAI'I ELECTRIC LIGHT COMPANY, INC.

ANNUAL SERVICE RELIABILITY REPORT

2016

Prepared by

Operations, Distribution Department

August 28, 2017

INTRODUCTION

This is the 2016 annual service reliability report of the Hawai'i Electric Light Company (HAWAI'I ELECTRIC LIGHT). The year-end average number of electric customers increased from 83,622 in 2015 to 84,367 in 2016 (0.89% increase). The 2016 peak demand for the system was 188.5 MW (evening peak), 3.0 MW lower than the peak demand of 191.5 MW in 2015.

The system interruption summaries (Attachment A) for the past year and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer.

Attachment B contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (ASAI), the frequency or number of times HAWAI'I ELECTRIC LIGHT's customers experience an outage during the year (SAIFI), the average length of time an interrupted customer is out of power (CAIDI), and the average length of time HAWAI'I ELECTRIC LIGHT's customers are out of power during the year (SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on HAWAI'I ELECTRIC LIGHT's total customer base (in this case 84,367 customers).

ANALYSIS

This analysis of the annual system reliability for HAWAI'I ELECTRIC LIGHT is for the year 2016. To determine the relative level of reliability, the statistics for five prior years, 2011 through 2015, are used for comparison.

The reliability indices are calculated using the data from all sustained¹ system outages except Customer Maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities," dated December 1990. The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

¹An electrical service interruption of more than one minute. (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

Hawai'i Electric Light Company, Inc.
Annual Service Reliability Report 2016

2016 RESULTS

Annual Service Reliability Indices

The reliability results for 2016 and five prior years are shown below in Table 1: Annual Service Reliability Indices – All Events and Table 2: Annual Service Reliability Indices – with Normalizations. Tables 3 - 8 break out the events into three groups, Transmission and Distribution, Generation – Hawaii Electric Light, and Generation – Other [non-utility] for all events and with normalization. Two T&D storm related events were normalized in 2016. All subsequent comparisons and discussion are based on the normalized data.

Table 1: Annual Service Reliability Indices - All Events

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	289,448	229,461	377,561	405,362	432,794	265,222
Customer-Hour Interruptions	245,465	191,973	277,087	1,320,024	668,864	251,314
SAID	182.28	141.27	202.58	955.7	479.92	178.73
CAID	50.88	50.2	44.03	195.38	92.73	56.85
SAIF	3.582	2.814	4.601	4.891	5.176	3.144
ASA	99.964	99.973	99.961	99.811	99.908	99.966

Table 2: Annual Service Reliability Indices - with Normalization

Year	2011*	2012	2013*	2014*	2015*	2016*
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	235,520	229,461	239,369	281,467	228,540	242,992
Customer-Hours Interrupted	235,894	191,973	155,975	222,297	209,464	191,143
SAID	175.17	141.27	114.03	160.94	150.29	135.94
CAID	60.1	50.2	39.1	47.39	54.99	47.20
SAIF	2.915	2.814	2.917	3.396	2.733	2.880
ASA	99.966	99.973	99.978	99.962	99.971	99.974

NOTE:

2011* Data normalized to exclude 6/30, Keahole CT4 UFLS
Data normalized to exclude 7/16, Keahole CT5 and ST7 UFLS
Data normalized to exclude 8/2, HEP UFLS
2013* Data normalized to exclude 1/25, 7600 Line fault
Data normalized to exclude 3/2, Keahole CT4 UFLS
Data normalized to exclude 3/13, 6500 Line fault
Data normalized to exclude 6/27, 8/14 Waimea Sub upgrade

Hawai'i Electric Light Company, Inc.
Annual Service Reliability Report 2016

Data normalized to exclude 7/29, Wind Storm
 Data normalized to exclude 10/26, 12/30 PGV UFLS
 Data normalized to exclude 11/25, Hill 6 UFLS
 Data normalized to exclude 12/30, Lightning Storm
 2014* Data normalized to exclude 1/22, Wind Storm
 Data normalized to exclude 4/12, Keahole CT 5 UFLS
 Data normalized to exclude 8/7, Hurricane Iselle
 2015* Data normalized to exclude 1/2, Wind Storm
 Data normalized to exclude 2/13, Wind Storm
 Data normalized to exclude 5/6, Keahole CT 5 UFLS
 Data normalized to exclude 6/25, Keahole CT 4 UFLS
 2016* Data normalized to exclude 7/23, Tropical Storm Darby
 Data normalized to exclude 8/31, Hurricane Madeline

Table 3: Transmission & Distribution Events

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	178,277	146,243	189,384	232,992	293,259	151,301
CID	230,936.3	184,668.8	256,892.7	1,294,789.2	648,887.9	229,528.9
SAID	171.49	135.89	187.81	937.44	465.59	163.24
CAID	77.72	75.77	81.39	333.43	132.76	91.02
SAIF	2.206	1.794	2.308	2.811	3.507	1.793

Table 4: Generation Events – Hawai'i Electric Light

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	8,2068	82,872	83,622	84,367
Customer Interruptions	57,396	31,421	117,362	118,641	128,579	76,217
CID	6,272.8	2,714.8	13,785	15,257.9	18,946.4	17,888.8
SAID	4.66	2.00	10.08	11.05	13.59	12.72
CAID	6.56	5.18	7.05	7.72	8.84	14.08
SAIF	0.71	0.385	1.43	1.432	1.538	0.903

Hawai'i Electric Light Company, Inc.
Annual Service Reliability Report 2016

Table 5: Generation Events – Other (non-utility)

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	53,775	51,797	70,815	53,729	10,956	37,704
CID	8,255.7	4,589.8	6,409.7	9,976.5	1,029.5	3,896.6
SAID	6.13	3.38	4.69	7.22	0.74	2.77
CAID	9.21	5.32	5.43	11.14	5.64	6.20
SAIF	0.666	0.635	0.863	0.648	0.131	0.447

Table 6: Transmission & Distribution Events with Normalization

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	178,277	146,243	125,999	141,684	130,329	129,071
CID	230,936.3	184,668.8	146,321.3	204,185.5	196,347.1	169,357.6
SAID	171.49	135.89	106.98	147.83	140.88	120.44
CAID	77.72	75.77	69.68	86.47	90.39	78.73
SAIF	2.206	1.794	1.535	1.710	1.559	1.530

Table 7: Generation Events – Hawai'i Electric Light with Normalization

Year	2011	2012	2013	2014	2015	2016
Number of Customers	80,800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	29,754	31,421	71,236	86,054	87,255	76,217
CID	3,061.3	2,714.8	6,375	8,134.9	12,087.2	17,888.8
SAID	2.27	2.00	4.66	5.89	8.67	12.72
CAID	6.17	5.18	5.37	5.67	8.31	14.08
SAIF	0.368	0.385	0.868	1.038	1.043	0.903

Table 8: Generation Events – Other (non-utility) with Normalization

Year	2011	2012	2013	2014	2015	2016
Number of Customers	8,0800	81,537	82,068	82,872	83,622	84,367
Customer Interruptions	27,489	51,797	42,134	53,729	10,956	37,704
CID	1,896	4,589.8	3,278.5	9,976.5	1,029.5	3,896.6
SAID	1.41	3.38	2.4	7.22	0.74	2.77
CAID	4.14	5.32	4.67	11.14	5.64	6.20
SAIF	0.340	0.635	0.513	0.648	0.131	0.447

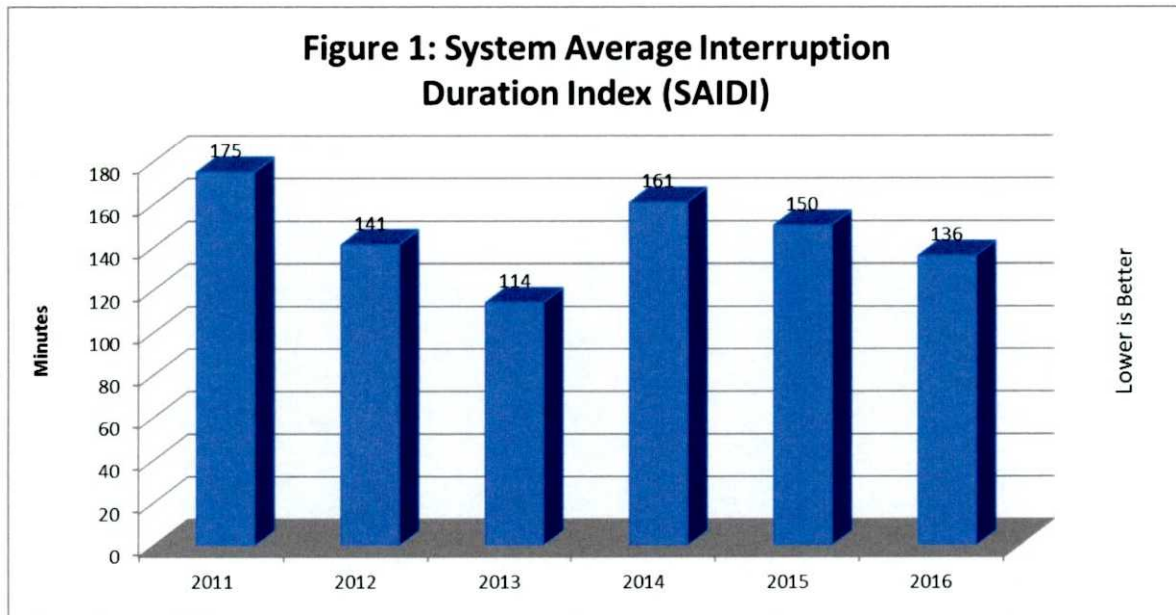


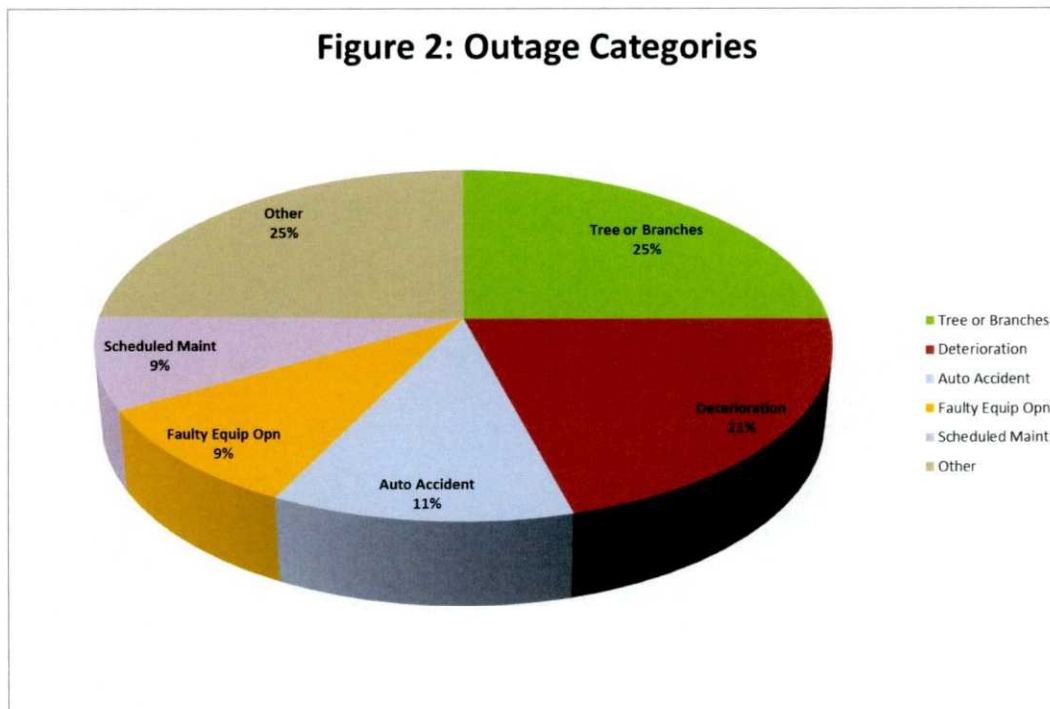
Figure 1 shows the System Average Interruption Duration Indices (SAIDI) for the past six years. It shows that the 2016 SAIDI is 136 minutes, a 9.3% decrease compared to the 2015 SAIDI result of 150 minutes. The SAIDI is the composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time.

In 2016, there were 12 sustained outages that resulted in the loss of more than 5,000 customers:

1. **February 20, 2016:** Underfrequency load shed event occurred when Keahole CT-4 tripped offline, affecting 5,661 customers for up to 7 minutes.
2. **February 20, 2016:** Generation shortfall manual load shed event occurred, affecting 26,149 customers for up to 108 minutes.
3. **April 13, 2016:** Underfrequency load shed event occurred when Hamakua Energy Partners CT-1 tripped offline, affecting 13,398 customers for up to 9 minutes.
4. **April 14, 2016:** Underfrequency load shed event occurred when Hamakua Energy Partners CT-2 tripped offline, affecting 10,028 customers for up to 8 minutes.
5. **April 15, 2016:** Underfrequency load shed event occurred when Keahole CT2 and Puna Steam Plant tripped offline, affecting 10,028 customers for up to 20 minutes.

6. **May 4, 2016:** Underfrequency load shed event occurred when 6600 transmission line tripped due to deteriorated conductor, affecting 16,900 customers for up to 57 minutes.
7. **July 1, 2016:** Underfrequency load shed event occurred when Keahole CT5 tripped offline, affecting 21,110 customers for up to 9 minutes.
8. **July 23, 2016:** Tropical Storm Darby, affecting 13,999 customers for up to 261 minutes.
9. **August 31, 2016:** Hurricane Madeline, affecting 5,684 customers for up to 51 minutes.
10. **September 8, 2016:** Overload during load transfer as part of switching, affecting 5,786 customers for up to 19 minutes.
11. **October 3, 2016:** Underfrequency load shed event occurred when Puna Geothermal Ventures tripped offline, affecting 14,278 customers for up to 16 minutes.
12. **October 10, 2016:** Underfrequency load shed event occurred when Hill 6 Plant tripped offline, affecting 14,278 customers for up to 11 minutes.

Hawai'i Electric Light Company, Inc.
Annual Service Reliability Report 2016



The Top 5 Outage Categories, by number of customer interruption hours affected, as illustrated in Figure 2, equates to about 75% of the total Customer hours in 2016. These top outage causes are:

<u>Outage Category</u>	<u>Sample Causes</u>
1. Trees/Branches	Contact by vegetation regardless of what caused it to make contact
2. Deterioration	Failed, broken corroded equipment
3. Automobile Accidents	Motor Vehicle Accidents
4. Faulty Equipment Operation	Hawai'i Electric Light and IPP generation load shedding
5. Scheduled Maintenance	Maintenance of T&D equipment in the system

The top two major cause factors for 2016 were Trees/Branches and Deterioration. The top 3rd, 4th and 5th major causes for 2016 were close to the same in values but were somewhat higher from 2015, whereas "System Add/Removal, Automobile Accidents and Faulty Equipment Operation" were replaced by "Automobile Accidents, Faulty Equipment Operation and Scheduled Maintenance."

A total of 242,992 Customer Interruptions were recorded for a total of 191,143 Customer Hours of Interruptions. The System Average Interruption Frequency (SAIF) index was 2.880 and the Customer Average Interruption Duration (CAID) was 47.20 minutes.

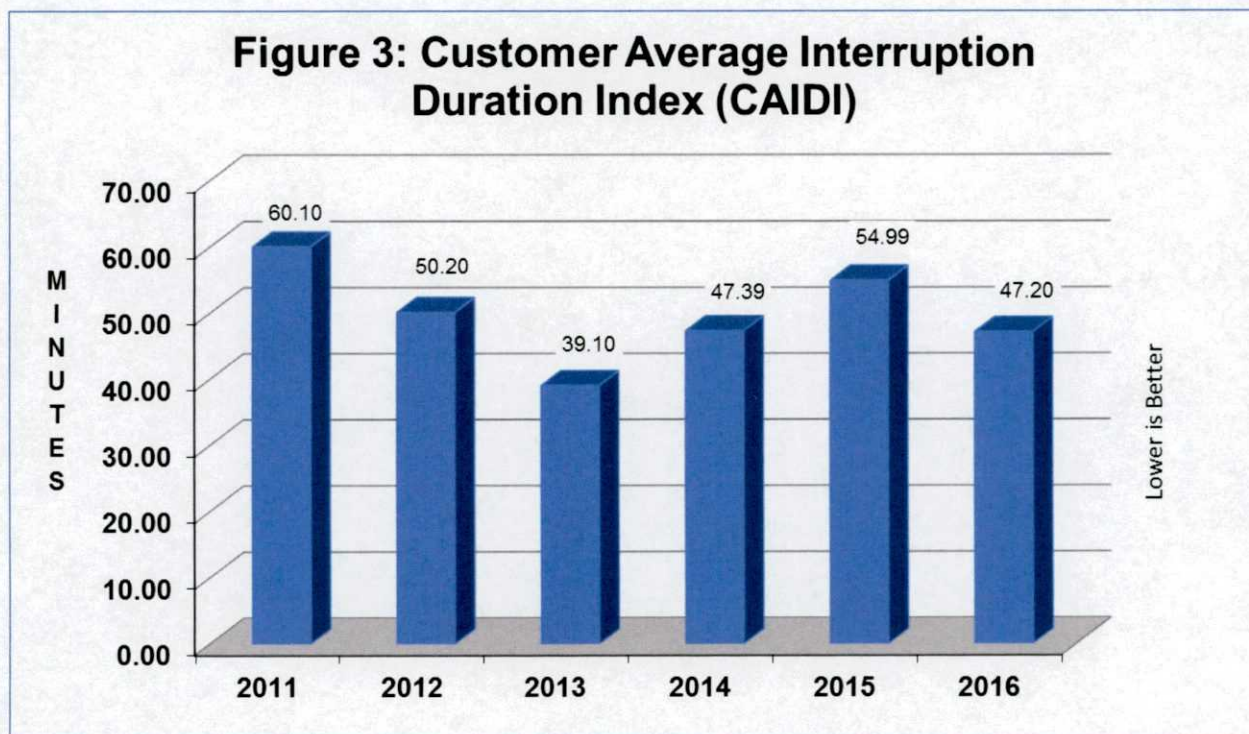


Figure 3 shows the Customer Average Interruption Duration Indices (CAIDI) for the past six years. The CAIDI for 2016 is 47.20 minutes, a 14% decrease compared to the 2015 CAIDI result of 54.99 minutes. In the six year period, 2016 was the second lowest year for CAIDI.

A contributing factor for the decrease in the annual 2016 CAIDI was shorter sustained outages due to trees and branches. In 2016, CAIDI caused by trees and branches was 99.41 minutes as compared to 104.70 minutes in 2015.

Three major events affecting the 2016 CAIDI results were:

1. November 4, 2016 – Waimea substation system upgrades which affected 2,049 customers in the North Kohala area and caused a sustained outage of approximately 7 hours. This event added 3.11 minutes to the annual 2016 CAIDI.
2. January 24, 2016 – Motor vehicle accident occurred at approximately 1 am and a distribution pole was severed in the Hawaiian Beaches area, which affected 2,548 customers. Various customers experienced a sustained outage up to 6.5 hours. This incident added 1.43 minutes to the annual 2016 CAIDI.
3. September 16, 2016 – Broken 34.5kV transmission pole due to deterioration affected 1,759 customers in the Pahoa area and caused a sustained outage up to 13 hours for some customers. This incident added 1.42 minutes to the annual 2016 CAIDI.

Hawai'i Electric Light Company, Inc.
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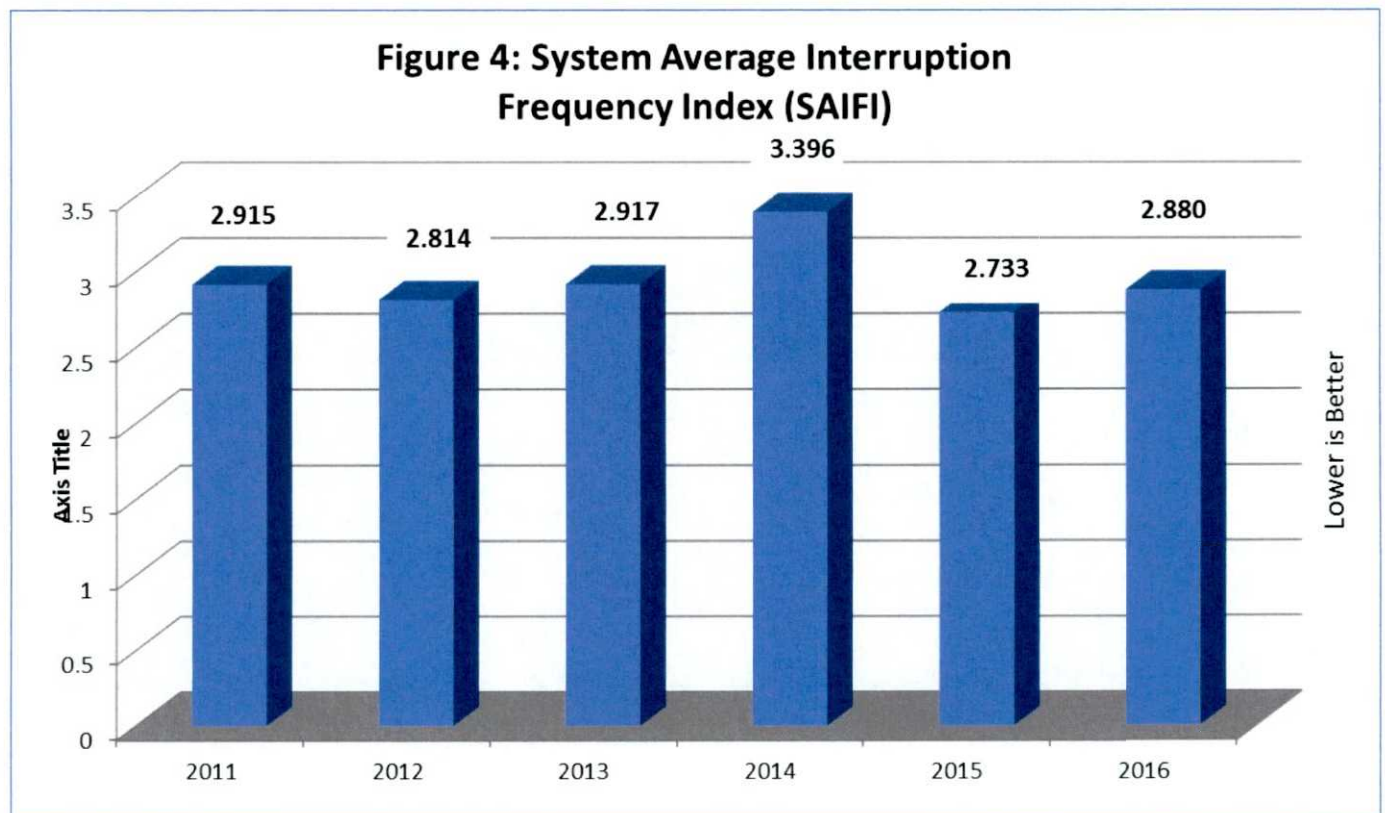


Figure 4 shows the System Average Interruption Frequency Index (SAIFI) increased from 2.733 in 2015 to 2.880 in 2016. 2016 had the third lowest customer interruption occurrences of the past six years.

Underfrequency load shed events continue to be the leading cause of customer interruptions, and also the largest contributing factor for the annual 2016 SAIFI. 2016 saw increase in SAIFI due to deterioration, with 44,943 customer interruptions in 2016 compared to 29,134 in 2015. Customer interruptions due to trees and branches dropped to the fourth cause in 2016.

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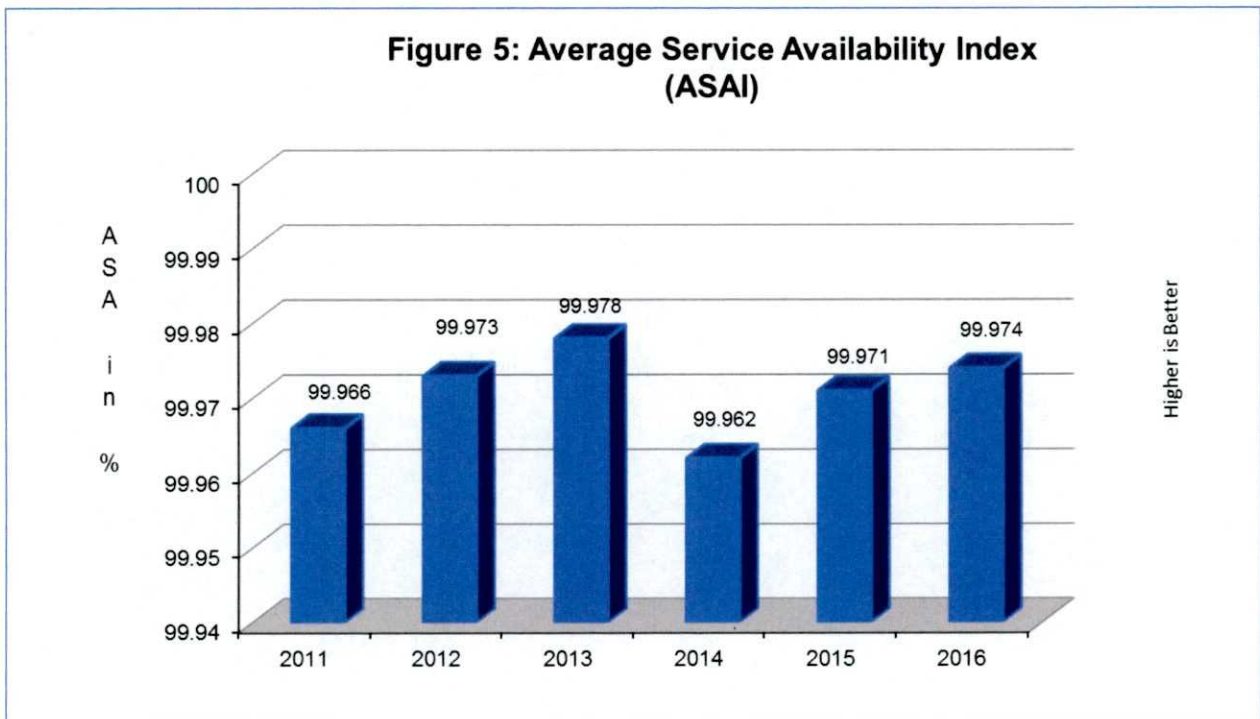


Figure 5 shows that the 2015 Average Service Availability Index was the second highest when compared to the prior five years. A decrease of customer-hour interruptions in 2016 shows a direct relationship to the increase of the ASAI in 2016. The top two SAIDI causes (as shown in above Figure 2), trees and branches, and deterioration, also account for the top two causes of customer-hour interruptions.

2016
SERVICE RELIABILITY SUMMARY
Normalized

Cause of Outage	CUST-HRS	CUST-INT	SAIF	SAID	CAID	MAIF	SAID Rank
Tree or Branches	47849.3	28881	0.342	34.03	99.41	0.642	1
Deterioration	39844.4	44943	0.533	28.34	53.19	0.281	2
Auto Accident	21824.9	11866	0.141	15.52	110.36	0.075	3
Faulty Equip Opn	18010.7	79306	0.940	12.81	13.63	0.063	4
Scheduled Maint	16247.9	3133	0.037	11.56	311.16	0.000	5
Unknown	11898.3	5086	0.060	8.46	140.37	0.205	6
Lightning	8468.4	1941	0.023	6.02	261.77	0.400	7
Cable Fault	7463.2	7020	0.083	5.31	63.79	0.048	8
Equip Contact	4152.3	2076	0.025	2.95	120.01	0.000	9
Customer Equip	3952.2	37727	0.447	2.81	6.29	0.000	10
Flashover	3177.5	2931	0.035	2.26	65.05	0.000	11
Sys Add/Removal	2265.8	538	0.006	1.61	252.70	0.000	12
Tsf Failure	1616.6	1555	0.018	1.15	62.38	0.010	13
Other Persnl Err	1244.3	10740	0.127	0.88	6.95	0.042	14
Man or Animal	992.3	456	0.005	0.71	130.56	0.010	15
Vandalism	917.3	194	0.002	0.65	283.69	0.000	16
Loose Connection	860.5	4294	0.051	0.61	12.02	0.000	17
Excavate Constr	139.1	53	0.001	0.10	157.51	0.000	18
High Wind	84.7	122	0.001	0.06	41.63	0.000	19
Forced Maint	79.3	95	0.001	0.06	50.05	0.000	20
Balance Load	19.6	7	0.000	0.01	168.00	0.000	21
Equip Overload	19.2	10	0.000	0.01	115.00	0.000	22
Tsf Overload	5.8	12	0.000	0.00	28.75	0.000	23
Equip Failure	5.8	3	0.000	0.00	115.00	0.000	24
Fire	2.6	2	0.000	0.00	78.50	0.000	25
Foreign Objects	1.3	1	0.000	0.00	79.00	0.000	26
(None)	0.0	0	0.000	0.00	0.00	0.000	27
Opn or Sw Error	0.0	0	0.000	0.00	0.00	0.000	28
Flood Tsunami	0.0	0	0.000	0.00	0.00	0.000	29
Transfer Load	0.0	0	0.000	0.00	0.00	0.000	30
Customer Maint	0.0	0	0.000	0.00	0.00	0.000	31
Balloon/Kite	0.0	0	0.000	0.00	0.00	0.000	32
TOTALS	191143.0	242992	2.880	135.94	47.20	1.776	

NUMBER OF CUSTOMERS FOR THE PERIOD = 84367

ASA = 99.974%

SAIF = SYSTEM AVERAGE INTERRUPTION FREQUENCY

SAID = SYSTEM AVERAGE INTERRUPTION DURATION

CAID = CUSTOMER AVERAGE INTERRUPTION DURATION

MAIF = MOMENTARY AVERAGE INTERRUPTION FREQUENCY

THE OUTAGE CAUSES ARE LISTED IN ORDER OF ITS SAIF

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Hawai'i Electric Light Company, Inc.
Annual Service Reliability Report 2016
Attachment A- Summaries

2016
SYSTEM INTERRUPTION CAUSE REPORT
Normalized

CAUSE		No. of Interruptions		Customer Hours	
NON-CONNECTED SYSTEM	(Totals)	639	35.54%	79850.9	41.78%
Tree or Branches		439	24.42%	47849.3	25.03%
Auto Accident		100	5.56%	21824.9	11.42%
Customer Equip		53	2.95%	3952.2	2.07%
Man or Animal		22	1.22%	992.3	0.52%
Equip Contact		8	0.44%	4152.3	2.17%
Excavate Constr		8	0.44%	139.1	0.07%
Vandalism		5	0.28%	917.3	0.48%
Fire		2	0.11%	2.6	0.00%
Balance Load		1	0.06%	19.6	0.01%
Foreign Objects		1	0.06%	1.3	0.00%
Flood Tsunami		0	0.00%	0.0	0.00%
Transfer Load		0	0.00%	0.0	0.00%
Balloon/Kite		0	0.00%	0.0	0.00%
ERROR	(Totals)	25	1.39%	1244.3	0.65%
Other Persnl Err		25	1.39%	1244.3	0.65%
Opn or Sw Error		0	0.00%	0.0	0.00%
WEATHER	(Totals)	200	11.12%	8553.0	4.47%
Lightning		198	11.01%	8468.4	4.43%
High Wind		2	0.11%	84.7	0.04%
EQUIPMENT FAILURE	(Totals)	557	30.98%	69381.1	36.30%
Deterioration		291	16.18%	39844.4	20.85%
Cable Fault		154	8.57%	7463.2	3.90%
Faulty Equip Opn		93	5.17%	18010.7	9.42%
Flashover		8	0.44%	3177.5	1.66%
Loose Connection		7	0.39%	860.5	0.45%
Equip Failure		3	0.17%	5.8	0.00%
Equip Overload		1	0.06%	19.2	0.01%
TRANSFORMER FAILURE	(Totals)	41	2.28%	1622.4	0.85%
Tsf Failure		39	2.17%	1616.6	0.85%
Tsf Overload		2	0.11%	5.8	0.00%
UNKNOWN AFTER TESTS AND INSPECTIONS	(Totals)	51	2.84%	11898.3	6.22%
Unknown		51	2.84%	11898.3	6.22%
MAINTENANCE	(Totals)	232	12.90%	16327.2	8.54%
Scheduled Maint		214	11.90%	16247.9	8.50%
Forced Maint		18	1.00%	79.3	0.04%
SYSTEM ADDITIONS OR REMOVALS	(Totals)	53	2.95%	2265.8	1.19%
Sys Add/Removal		53	2.95%	2265.8	1.19%
TOTALS		1798		191143.0	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

DEFINITION OF TERMS

OUTAGE

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

INTERRUPTION

The loss of service to one or more consumers and is a result of one or more component outages.

INTERRUPTION DURATION

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

MOMENTARY INTERRUPTION

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities" indicated that momentary interruptions will have duration of one minute or less.

SUSTAINED INTERRUPTION

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities," dated December 1990, a sustained interruption has duration of greater than one minute.

CUSTOMER INTERRUPTION

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., Customer Maintenance) are not considered.

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Four reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

RELIABILITY INDICES

AVERAGE SERVICE AVAILABILITY INDEX (ASA)

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$

MAUI ELECTRIC COMPANY, LIMITED
ANNUAL SERVICE RELIABILITY REPORT
2016

Prepared by
System Operations Department

June 1, 2017

INTRODUCTION

This is the 2016 annual service reliability report for Maui Electric Company, Limited (MECO). The year-end average number of electric customers increased from 70,303 in 2015 to 70,745 in 2016 (a 0.63% increase). The 2016 peak demand for the system was 205.4 MW (gross) set on August 24, 2016, at 7:23pm, 1.2 MW lower than the peak demand of 206.6 MW (gross) set in 2015; the highest system peak demand remains at 210.9 MW (gross) set on October 11, 2004, at approximately 6:45 p.m.

The system interruption summaries (Attachments A and B) for the past year and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer.

Attachment C, contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (ASAI), the frequency or number of times MECO's customers experience an outage during the year (SAIFI), the average length of time an interrupted customer is out of power (CAIDI), and the average length of time MECO's customers are out of power during the year (SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on MECO's total customer base (in this case 70,745 customers).

ANALYSIS

This analysis of the annual system reliability for MECO is for the year 2016. To determine the relative level of reliability, the statistics for five prior years, 2011 through 2015, are used for comparison.

The reliability indices are calculated using the data from all sustained¹ system outages except customer maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990. The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

¹ An electrical service interruption of more than one minute (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

2016 RESULTS

Annual Service Reliability Indices

The annual service reliability for 2016 was ranked second best for SAIDI, SAIFI and ASA and ranked fourth best for CAIDI in comparison to the prior 5 years in terms of the indices for all events. The reliability results for all events in 2016 and five prior years are shown below in Table 1 through Table 4. The normalized reliability results in 2016 and five prior years are shown below in Table 5 through Table 8. The reliability results comparing T&D and generation related outages with all events in 2016 and five prior years are shown below in Table 9 through Table 16. The normalized reliability results comparing T&D and generation related outages in 2016 and five prior years are shown below in Table 17 through Table 24.

Table 1: Annual Service Reliability Indices – All Islands with All Events

	2011	2012	2013	2014	2015	2016
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	170,379	195,618	138,480	179,256	230,381	145,741
Customer-Hours Interrupted	210,185.7	248,500.5	221,000.3	219,243.8	534,259.8	220,551.2
SAIDI (Minutes)	185.43	217.43	191.33	188.39	455.96	187.05
CAIDI (Minutes)	74.02	76.22	95.75	73.38	139.14	90.80
SAIFI (Occurrence)	2.505	2.853	1.998	2.567	3.277	2.060
ASA (Percent)	99.9646%	99.9586%	99.9635%	99.9641%	99.9130%	99.9644%

Table 2: Annual Service Reliability Indices – Maui with All Events

	2011	2012	2013	2014	2015	2016
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	156,145	181,244	100,316	145,117	206,126	122,266
Customer-Hours Interrupted	194,603.0	199,620.7	171,316.7	167,244.6	505,698.0	177,909.2
SAIDI (Minutes)	184.68	187.89	159.62	154.60	464.01	162.23
CAIDI (Minutes)	74.78	66.08	102.47	69.15	147.20	87.31
SAIFI (Occurrence)	2.470	2.843	1.558	2.236	3.152	1.858
ASA (Percent)	99.9648%	99.9643%	99.9695%	99.9705%	99.9115%	99.9691%

Table 3: Annual Service Reliability Indices – Molokai with All Events

	2011	2012	2013	2014	2015	2016
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	8,018	12,171	33,224	21,114	18,192	17,610
Customer-Hours Interrupted	7,022.2	47,466.7	44,162.1	35,756.2	23,109.6	38,058.3
SAIDI (Minutes)	133.29	893.63	826.75	672.32	434.26	710.93
CAIDI (Minutes)	52.55	234.00	79.75	101.61	76.22	129.67
SAIFI (Occurrence)	2.537	3.819	10.366	6.617	5.697	5.483
ASA (Percent)	99.9746%	99.8300%	99.8423%	99.8717%	99.9172%	99.8647%

Table 4: Annual Service Reliability Indices – Lanai with All Events

	2011	2012	2013	2014	2015	2016
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	6,216	2,203	4,940	13,025	6,063	5,865
Customer-Hours Interrupted	8,560.4	1,413.1	5,521.5	16,243.1	5,452.1	4,583.8
SAIDI (Minutes)	316.27	51.60	194.65	565.30	190.19	158.70
CAIDI (Minutes)	82.63	38.49	67.06	74.82	53.95	46.89
SAIFI (Occurrence)	3.828	1.341	2.902	7.555	3.525	3.384
ASA (Percent)	99.9397%	99.9902%	99.9629%	99.8922%	99.9637%	99.9698%

Table 5: Annual Service Reliability Indices - All Islands with Normalization

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	101,268	81,428	71,894	107,847	112,984	115,289
Customer-Hours Interrupted	145,710.8	125,836.1	108,360.7	120,684.7	177,063.2	181,935.4
SAIDI (Minutes)	128.55	110.10	93.81	103.70	151.11	154.30
CAIDI (Minutes)	86.33	92.72	90.43	67.14	94.03	94.68
SAIFI (Occurrence)	1.489	1.187	1.037	1.545	1.607	1.630
ASA (Percent)	99.9755%	99.9791%	99.9821%	99.9802%	99.9712%	99.9706%

Table 6: Annual Service Reliability Indices - Maui with Normalization

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	99,729	77,968	64,459	102,328	104,287	105,595
Customer-Hours Interrupted	144,404.5	119,045.4	101,098.4	114,071.1	165,638.5	161,332.1
SAIDI (Minutes)	137.04	112.05	94.20	105.44	151.99	147.11
CAIDI (Minutes)	86.88	91.61	94.10	66.89	95.30	91.67
SAIFI (Occurrence)	1.577	1.223	1.001	1.576	1.595	1.605
ASA (Percent)	99.9739%	99.9787%	99.9820%	99.9799%	99.9710%	99.9720%

Table 7: Annual Service Reliability Indices - Molokai with Normalization

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	1,252	3,229	6,180	4,064	8,159	8,783
Customer-Hours Interrupted	1,218.5	6,338.9	5,942.2	4,870.6	10,901.8	20,131.1
SAIDI (Minutes)	23.13	119.34	111.24	91.58	204.86	376.05
CAIDI (Minutes)	58.39	117.79	57.69	71.91	80.17	137.52
SAIFI (Occurrence)	0.396	1.013	1.928	1.274	2.555	2.734
ASA (Percent)	99.9956%	99.9773%	99.9788%	99.9825%	99.9609%	99.9285%

Table 8: Annual Service Reliability Indices - Lanai with Normalization

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	287	231	1,255	1,455	538	911
Customer-Hours Interrupted	87.8	451.7	1,320.1	1,742.9	522.9	472.2
SAIDI (Minutes)	3.24	16.50	46.54	60.66	18.24	16.35
CAIDI (Minutes)	18.36	117.33	63.11	71.87	58.32	31.10
SAIFI (Occurrence)	0.177	0.141	0.737	0.844	0.313	0.526
ASA (Percent)	99.9994%	99.9969%	99.9911%	99.9884%	99.9965%	99.9969%

NOTE:

2011*	Data normalized to exclude the 01/10/11 High Winds Data normalized to exclude the 01/12/11 – 01/14/11 High Winds and Lightning Storm Data normalized to exclude the 12/24/11 High Winds Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2012*	Data normalized to exclude the 02/7/12 – 02/08/12 High Winds Data normalized to exclude the 09/5/12 Operator Error Data normalized to exclude the 11/6/12 Flashover Data normalized to exclude the 12/4/12 Substation Fire Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2013*	Data normalized to exclude the 01/2/13 Trees in Transmission Lines Data normalized to exclude the 07/29/13 – 07/30/13 Tropical Storm Flossie Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2014*	Data normalized to exclude the 5/9/14 Flashover on the Maalaea/Kihei 69KV Line Data normalized to exclude the 08/7/14 – 08/9/14 Tropical Storm Iselle Data normalized to exclude the 10/7/14 Equipment failure Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2015*	Data normalized to exclude the 01/2/15 – 01/4/15 Kona Storm Data normalized to exclude the 02/13/15 – 02/15/15 Valentine's Day Storm Data normalized to exclude the 04/18/15 Equipment Failure Data normalized to exclude the 12/18/15 Equipment Failure Data normalized to exclude various equipment failures and faults on Lanai and Moloka'i
2016*	Data normalized to exclude the 07/2/16 West Maui Mountains wild fire Data normalized to exclude various equipment failures and faults on Lanai and Moloka'i

T&D vs. Generation – All Events

Table 9: Annual Service Reliability Indices for All Islands – T&D

	2011	2012	2013	2014	2015	2016
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	129,554	120,420	88,944	155,067	202,029	138,433
Customer-Hours Interrupted	188,364.0	182,315.6	186,857.1	198,535.5	516,408.0	213,354.0
SAIDI (Minutes)	166.18	159.52	161.77	170.60	440.73	180.95
CAIDI (Minutes)	87.24	90.84	126.05	76.82	153.37	92.47
SAIFI (Occurrence)	1.905	1.756	1.283	2.221	2.874	1.957
ASA (Percent)	99.9683%	99.9697%	99.9691%	99.9675%	99.9159%	99.9656%

Table 10: Annual Service Reliability Indices for All Islands - Generation

	2011	2012	2013	2014	2015	2016
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	40,825	75,198	49,536	24,189	28,352	7,308
Customer-Hours Interrupted	21,821.7	66,185.0	34,143.2	20,708.3	17,851.8	7,197.3
SAIDI (Minutes)	19.25	57.91	29.56	17.79	15.24	6.10
CAIDI (Minutes)	32.07	52.81	41.36	51.37	37.78	59.09
SAIFI (Occurrence)	0.600	1.097	0.715	0.346	0.403	0.103
ASA (Percent)	99.9963%	99.9890%	99.9944%	99.9966%	99.9971%	99.9988%

Table 11: Annual Service Reliability Indices for Maui – T&D

	2011	2012	2013	2014	2015	2016
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	121,962	109,200	73,357	131,670	185,303	122,263
Customer-Hours Interrupted	179,049.6	134,348.7	159,261.0	159,909.0	494,145.2	177,896.4
SAIDI (Minutes)	169.92	126.46	148.39	147.82	453.41	162.22
CAIDI (Minutes)	88.08	73.82	130.26	72.87	160.00	87.30
SAIFI (Occurrence)	1.929	1.713	1.139	2.029	2.834	1.858
ASA (Percent)	99.9676%	99.9759%	99.9717%	99.9718%	99.9135%	99.9691%

Table 12: Annual Service Reliability Indices for Maui - Generation

	2011	2012	2013	2014	2015	2016
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	34,183	72,044	26,959	13,447	20,823	3
Customer-Hours Interrupted	15,553.4	65,272.0	12,055.7	7,335.6	11,552.9	12.8
SAIDI (Minutes)	14.76	61.44	11.23	6.78	10.60	0.01
CAIDI (Minutes)	27.30	54.36	26.83	32.73	33.29	255.00
SAIFI (Occurrence)	0.541	1.130	0.419	0.207	0.318	0.001
ASA (Percent)	99.9972%	99.9883%	99.9979%	99.9987%	99.9980%	99.9999%

Table 13: Annual Service Reliability Indices for Molokai – T&D

	2011	2012	2013	2014	2015	2016
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	3,261	10,338	12,730	18,190	14,373	15,259
Customer-Hours Interrupted	2,753.4	47,081.8	23,428.8	32,789.8	19,414.8	34,985.3
SAIDI (Minutes)	52.26	886.38	438.60	616.54	364.82	653.52
CAIDI (Minutes)	50.66	273.25	110.43	108.16	81.05	137.57
SAIFI (Occurrence)	1.032	3.244	3.972	5.700	4.501	4.751
ASA (Percent)	99.9900%	99.8314%	99.9163%	99.8824%	99.9304%	99.8757%

Table 14: Annual Service Reliability Indices for Molokai - Generation

	2011	2012	2013	2014	2015	2016
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	4,757	1,833	20,494	2,924	3,819	2,351
Customer-Hours Interrupted	4,268.9	385.0	20,733.4	2,966.4	3,694.9	3,072.9
SAIDI (Minutes)	81.03	7.25	388.14	55.78	69.43	57.40
CAIDI (Minutes)	53.84	12.60	60.70	60.87	58.05	78.42
SAIFI (Occurrence)	1.505	0.575	6.394	0.916	1.196	0.732
ASA (Percent)	99.9845%	99.9986%	99.9259%	99.9894%	99.9868%	99.9891%

Table 15: Annual Service Reliability Indices for Lanai – T&D

	2011	2012	2013	2014	2015	2016
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	4,331	882	2,857	5,207	2,353	911
Customer-Hours Interrupted	6,561.0	885.1	4,167.4	5,836.8	2,848.0	472.2
SAIDI (Minutes)	242.40	32.32	146.91	203.14	99.35	16.35
CAIDI (Minutes)	90.89	60.21	87.52	67.26	72.62	31.10
SAIFI (Occurrence)	2.667	0.537	1.679	3.020	1.368	0.526
ASA (Percent)	99.9538%	99.9939%	99.9720%	99.9612%	99.9810%	99.9969%

Table 16: Annual Service Reliability Indices for Lanai - Generation

	2011	2012	2013	2014	2015	2016
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	1,885	1,321	2,083	7,818	3,710	4,954
Customer-Hours Interrupted	1,999.5	528.0	1,354.1	10,406.3	2,604.1	4,111.6
SAIDI (Minutes)	73.87	19.28	47.74	362.17	90.84	142.35
CAIDI (Minutes)	63.64	23.98	39.00	79.86	42.11	49.80
SAIFI (Occurrence)	1.161	0.804	1.224	4.535	2.157	2.859
ASA (Percent)	99.9859%	99.9963%	99.9909%	99.9309%	99.9827%	99.9729%

T&D vs. Generation – With Normalization

Table 17: Normalized Annual Service Reliability Indices for All Islands – T&D

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	92,997	53,218	59,404	94,451	110,133	115,286
Customer-Hours Interrupted	139,223.9	111,142.1	101,339.0	113,310.1	172,681.4	181,922.7
SAIDI (Minutes)	122.83	97.24	87.74	97.37	147.37	154.29
CAIDI (Minutes)	89.82	125.31	102.36	71.98	94.08	94.68
SAIFI (Occurrence)	1.435	0.776	0.857	1.353	1.567	1.630
ASA (Percent)	99.9766%	99.9815%	99.9833%	99.9814%	99.9719%	99.9706%

Table 18: Normalized Annual Service Reliability Indices for All Islands – Generation

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	68,010	68,575	69,303	69,825	70,303	70,745
Customer Interruptions	8,271	28,210	12,490	13,396	2,851	3
Customer-Hours Interrupted	6,486.9	14,694.0	7,021.7	7,374.6	4,381.8	12.8
SAIDI (Minutes)	5.72	12.86	6.08	6.34	3.74	0.01
CAIDI (Minutes)	47.06	31.25	33.73	33.03	92.22	255.00
SAIFI (Occurrence)	0.054	0.411	0.180	0.192	0.041	0.001
ASA (Percent)	99.9989%	99.9976%	99.9988%	99.9988%	99.9993%	99.9999%

Table 19: Normalized Annual Service Reliability Indices for Maui – T&D

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	91,828	50,306	54,680	89,101	101,454	105,592
Customer-Hours Interrupted	137,980.4	104,638.8	96,167.0	106,764.9	161,264.7	161,319.4
SAIDI (Minutes)	130.94	98.49	89.60	98.69	147.97	147.10
CAIDI (Minutes)	90.16	124.80	105.52	71.89	95.37	91.67
SAIFI (Occurrence)	1.452	0.789	0.849	1.373	1.552	1.605
ASA (Percent)	99.9800%	99.9813%	99.9829%	99.9812%	99.9718%	99.9720%

Table 20: Normalized Annual Service Reliability Indices for Maui – Generation

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	63,225	63,745	64,397	64,909	65,390	65,799
Customer Interruptions	7,901.0	27,662.0	9,779	13,227	2,833	3
Customer-Hours Interrupted	6,424.1	14,406.7	4,931.4	7,306.3	4,373.9	12.8
SAIDI (Minutes)	6.10	13.56	4.59	6.75	4.01	0.01
CAIDI (Minutes)	48.78	31.25	30.26	33.14	92.63	255.00
SAIFI (Occurrence)	0.125	0.434	0.152	0.204	0.043	0.001
ASA (Percent)	99.9988%	99.9974%	99.9991%	99.9987%	99.9992%	99.9999%

Table 21: Normalized Annual Service Reliability Indices for Molokai – T&D

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	1,102	2,752	3,487	4,064	8,159	8,783
Customer-Hours Interrupted	1,163.5	6,067.0	3,856.5	4,870.6	10,901.8	20,131.1
SAIDI (Minutes)	22.08	114.22	72.20	91.58	204.86	376.05
CAIDI (Minutes)	63.35	132.27	66.36	71.91	80.17	137.52
SAIFI (Occurrence)	0.349	0.864	1.088	1.274	2.555	2.734
ASA (Percent)	99.9958%	99.9783%	99.9862%	99.9825%	99.9609%	99.9285%

Table 22: Normalized Annual Service Reliability Indices for Molokai – Generation

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	3,161	3,187	3,205	3,191	3,193	3,212
Customer Interruptions	150	477	2,693	0	0	0
Customer-Hours Interrupted	55.0	272.0	2,085.7	0.0	0.0	0.0
SAIDI (Minutes)	1.04	5.12	39.05	0.00	0.00	0.00
CAIDI (Minutes)	22.00	34.21	46.47	0.00	0.00	0.00
SAIFI (Occurrence)	0.047	0.150	0.840	0.000	0.000	0.000
ASA (Percent)	99.9998%	99.9990%	99.9926%	100.0000%	100.0000%	100.0000%

Table 23: Normalized Annual Service Reliability Indices for Lanai – T&D

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	67	160	1,237	1,286	520	911
Customer-Hours Interrupted	80.0	436.3	1,315.6	1,674.7	515.0	472.2
SAIDI (Minutes)	2.96	15.93	46.38	58.28	17.96	16.35
CAIDI (Minutes)	71.66	163.61	63.81	78.13	59.42	31.10
SAIFI (Occurrence)	0.041	0.097	0.727	0.746	0.302	0.526
ASA (Percent)	99.9994%	99.9970%	99.9912%	99.9889%	99.9966%	99.9969%

Table 24: Normalized Annual Service Reliability Indices for Lanai – Generation

	2011*	2012*	2013*	2014*	2015*	2016*
Number of Customers	1,624	1,643	1,702	1,724	1,720	1,733
Customer Interruptions	220	71	18	169	18	0
Customer-Hours Interrupted	7.8	15.4	4.5	68.3	8.0	0.0
SAIDI (Minutes)	0.29	0.56	0.16	2.38	0.28	0.00
CAIDI (Minutes)	2.13	13.03	15.00	24.24	26.50	0.00
SAIFI (Occurrence)	0.135	0.043	0.011	0.098	0.010	0.000
ASA (Percent)	99.9999%	99.9999%	100.0000%	99.9995%	99.9999%	100.0000%

Figure 1: System Average Interruption Duration Index (SAIDI)

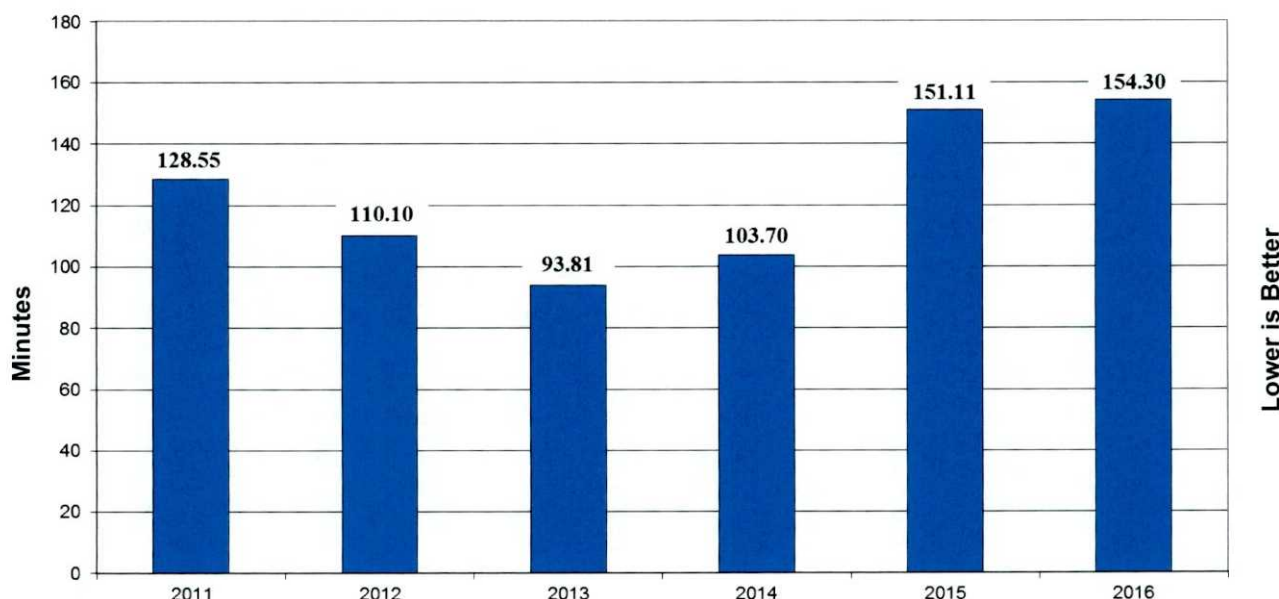


Figure 1 shows the System Average Interruption Duration Indices (SAIDI) for 2016 and the past five years normalized. It shows that the 2016 SAIDI is 154.30 minutes, a 2.11% increase compared to the 2015 SAIDI result of 151.11 minutes. The SAIDI is a composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time. The higher SAIDI result for 2016 was due to an increase in both the number of customer interruptions and the duration of the customer interruptions.

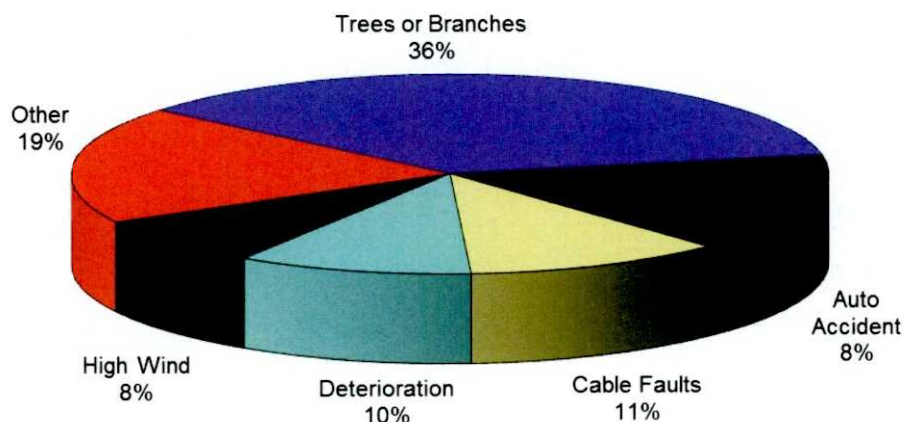
The six major events impacting the 2016 SAIDI were:

1. **March 25, 2016:** Maui experienced a major outage event when the 23KV circuit breaker 2503 in Wailuku tripped during a period of heavy rain and high wind due to wind driven debris contacting the 23KV conductors affecting 3,758 customers for up to 2 hours 56 minutes.
2. **April 3, 2016:** Maui experienced a major outage event when the Mahinahina circuit breaker 1219 tripped due to a vehicle/pole accident affecting 2,673 customers for up to 12 hours 24 minutes.
3. **August 10, 2016:** Maui experienced a major outage event when the Hana 23KV line and the Kuau recloser 4066 tripped due to a vehicle/pole accident affecting 6,394 customers for up to 12 hours 44 minutes.
4. **September 25, 2016:** Maui experienced a major outage event when the Kihei circuit breaker 1285 tripped due to a failed guy wire and anchor that resulted in the downing of a pole affecting 3,448 customers for up to 11 hours 57 minutes.
5. **December 18, 2016:** Maui experienced a major outage event when the Kula circuit breaker 1237 tripped during a period of heavy rain and high wind due to tree branches making contact with the primary conductors affecting 1,487 customers for up to 7 hours 17 minutes.

6. **December 18, 2016:** Maui experienced a major outage event when the Kula circuit breaker 1238 tripped during a period of heavy rain and high wind. High winds were reported as the outage cause affecting 1,614 customers for up to 4 hours 57 minutes.

These six events increased the 2016 SAIDI by 48.63 minutes.

Figure 2: Top 5 Outage Categories



The top 5 outage categories, by number of customer interruption hours, as illustrated in Figure 2, equates to about 81% of the total customer interruption hours in 2016; these causes are:

<u>Outage Category</u>	<u>Sample Causes</u>
1. Trees or Branches in Lines	Trees falling or contacting overhead lines
2. Automobile Accidents	Downed poles due to vehicles accidents
3. Cable Faults	Underground equipment failures
4. Deterioration, Rot, Corrosion, Termites	Failed or broken equipment due to corrosion
5. High Winds	Broken equipment due to high winds

The top 5 major cause factors for 2016, based on customer interruption hours, varied in comparison to 2015. While "Trees and Branches in Lines", "Automobile Accidents" and "Deterioration, Rot, Corrosion, Termites" remained in the top 5 causes, "Unknown Failures" and "Mylar Balloons" were replaced by "Cable Faults" and "High Winds". The total number of customer interruption hours increased in 2016, which was 181,935.4 hours, compared with 177,063.2 hours in 2015. 2016 also had the highest number of customer interruption hours in the six year period (normalized).

The number of customer interruption hours for one major cause did decrease in 2016. This cause was "Trees and Branches in Lines". The number of customer interruption hours due to "Trees and Branches in Lines" decreased from 73,417.3 hours in 2015 to 64,843.4 hours in 2016.

However, the number of customer interruption hours for four other major causes did increase in 2016. These causes were "Automobile Accidents", "Cable Faults", "Deterioration, Rot, Corrosion, Termites" and "High Winds". The number of customer interruption hours due to "Auto Accidents" increased from 13,393.8 hours in 2015 to 29,442.0 hours in 2016, the number of customer interruption hours due to "Cable Faults" increased from 8,369.6 hours in 2015 to 19,111.0 hours in 2016, the number of customer interruption hours due to "Deterioration, Rot, Corrosion, Termites" increased from 13,320.0 hours in 2015 to 17,276.7 hours in 2016 and the number of customer interruption hours due to "High Winds" increased from 10,540.8 hours in 2015 to 13,799.0 hours in 2016.

Figure 3: Customer Average Interruption Duration Index (CAIDI)

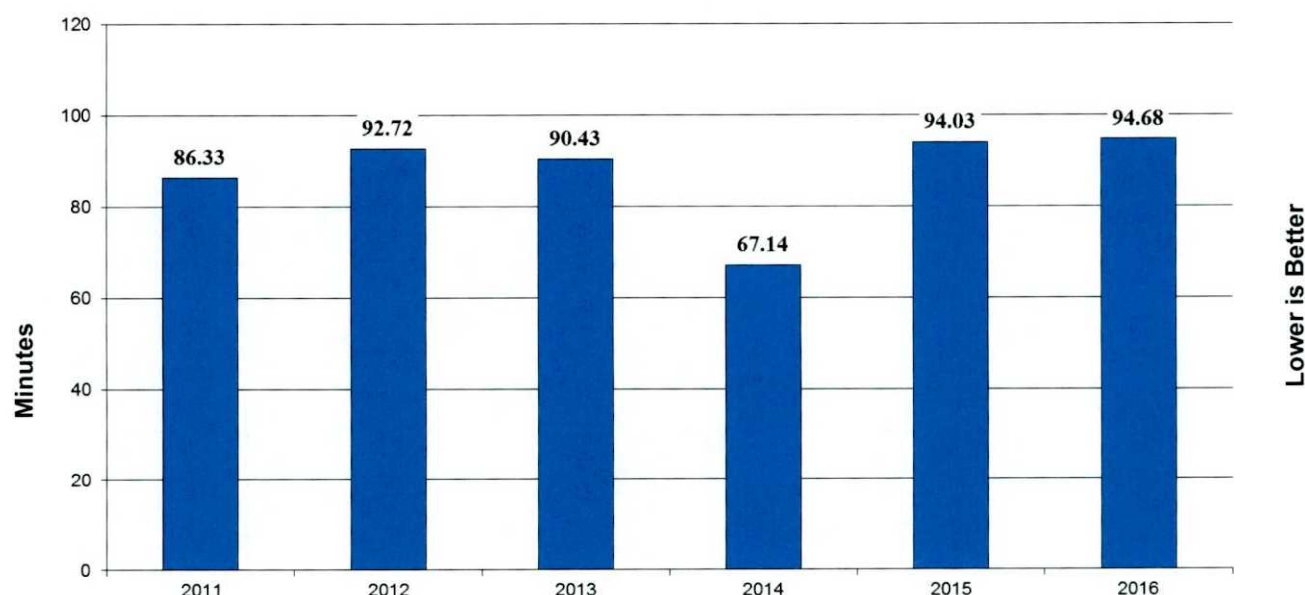


Figure 3 shows the Customer Average Interruption Duration Indices (CAIDI) for 2016 and the past five years normalized. It shows that the average duration of a customer's outage (CAIDI) for 2016 is 94.68 minutes, a 0.69% increase compared to the 2015 CAIDI result of 94.03 minutes. In the six year period, 2016 was the worst performing year for CAIDI.

The contributing factor to the increase of the CAIDI index from 2016 was a greater number of customers being affected by longer outage durations related to interruptions due to "Automobile Accidents", "Cable Faults" and Foreign Objects in Lines or Equipment".

The CAIDI for "Automobile Accidents" increased in 2016, which incurred 15.32 minutes, as compared to 7.11 minutes in 2015. The CAIDI for "Cable Faults" increased in 2016, which incurred 9.95 minutes, as compared to 4.44 minutes in 2015 and the CAIDI for "Foreign Objects in Lines or Equipment" also increased in 2016, which incurred 4.19 minutes, as compared to 0.87 minutes in 2015.

The five major events affecting the 2016 CAIDI results were:

1. **March 25, 2016:** The 23KV circuit breaker 2503 in Wailuku tripped during a period of heavy rain and high wind due to wind driven debris contacting the 23KV conductors affecting 3,758 customers for up to 2 hours 56 minutes.
2. **April 3, 2016:** The Mahinahina circuit breaker 1219 tripped due to a vehicle/pole accident affecting 2,673 customers for up to 12 hours 24 minutes.
3. **September 25, 2016:** The Kihei circuit breaker 1285 tripped due to a failed guy wire and anchor that resulted in the downing of a pole affecting 3,448 customers for up to 11 hours 57 minutes.
4. **December 18, 2016:** The Kula circuit breaker 1237 tripped during a period of heavy rain and high wind due to tree branches making contact with the primary conductors affecting 1,487 customers for up to 7 hours 17 minutes.
5. **December 18, 2016:** The Kula circuit breaker 1238 tripped during a period of heavy rain and high wind. High winds were reported as the outage cause affecting 1,614 customers for up to 4 hours 57 minutes.

These five events increased the 2016 CAIDI by 26.85 minutes.

Figure 4: System Average Interruption Frequency Index (SAIFI)

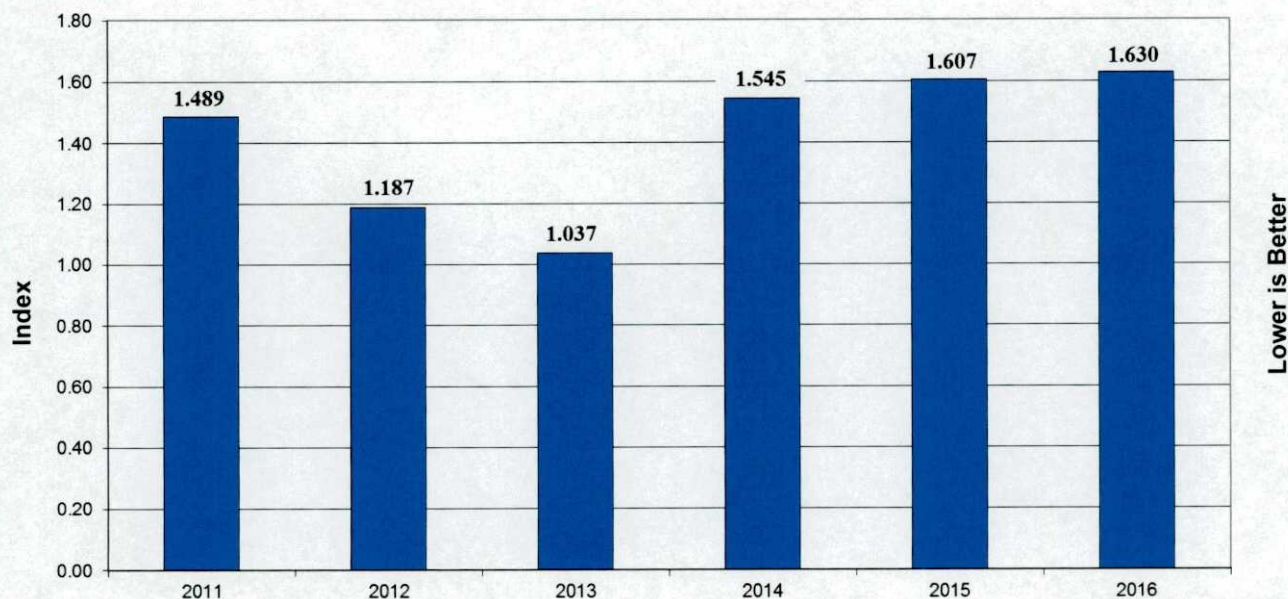


Figure 4 shows the System Average Interruption Frequency Index (SAIFI) for 2016 and the past five years normalized. It shows that the 2016 SAIFI was 1.630, an increase of 1.43% compared to the 2015 SAIFI result of 1.607. The number of customer interruptions in 2016 was 115,289 as compared to 112,984 customer interruptions in 2015. In the past six years, 2016 had the most customer interruptions and was the worst performing year for SAIFI.

Maui Electric did see a decrease in customer interruptions due to outages caused by “Unknown Failures”, “Mylar Balloons” and “High Winds”, but these decreases were offset by higher customer interruptions due to other causes. The contributing factor to the increase of the 2016 SAIFI index from 2015 was from the rise in the number of customer interruptions especially related to “Cable Faults”, “Equipment Failures” and “Automobile Accidents”.

The number of customer interruptions due to “Cable Faults” increased in 2016, which incurred 15,561 customer interruptions, as compared to 5,246 customer interruptions in 2015. The number of customer interruptions due to “Equipment Failures” increased in 2016, which incurred 9,784 customer interruptions, as compared to 4,239 customer interruptions in 2015. The number of customer interruptions due to “Automobile Accidents” also increased in 2016, which incurred 13,776 customer interruptions, as compared to 9,094 customer interruptions in 2015.

Figure 5: Average Service Availability Index (ASAI)

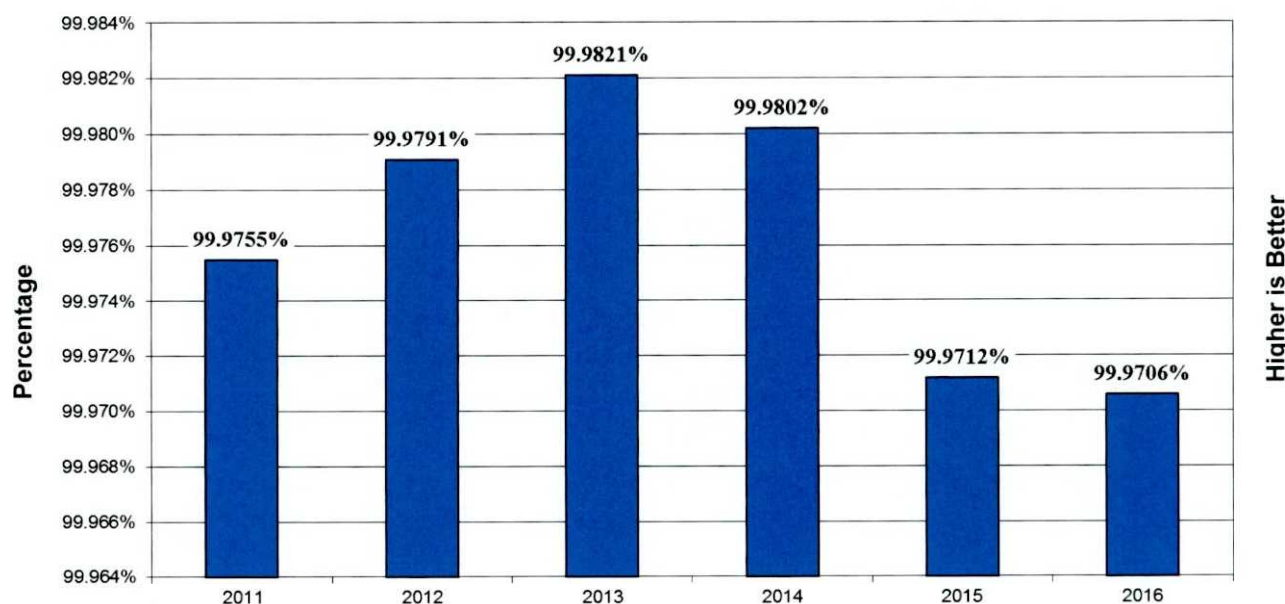


Figure 5 shows that the 2016 Average Service Availability Index decreased as compared to the 2015 results normalized. It shows that the 2016 ASAI was 99.9706%, a decrease of 0.0006% compared to the 2015 ASAI result of 99.9712%. In the six year period, 2015 was the worst performing year for ASAI.

The ASAI is a percentage of the total number of customer hours that service was available to customers during the year compared to the total customer hours possible and produces a generalized standard of system reliability by combining both the durations and the number of customers affected. The contributing factor to the decrease of the ASAI in 2016 was an increase of both the number of customers interrupted and the durations of the

interruptions. The total number of customer hour interruptions in 2016 was 181,935.4 hours as compared to 177,063.2 hours in 2015, an increase of 2.75%.

Attachment-A

Maui Electric Company **Normalized Sustained Interruption Summary – System Total**

FROM: JANUARY 1, 2016

TO: DECEMBER 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
TREES OR BRANCHES IN LINES	64,843.4	32,710	0.462	54.99	118.94
AUTOMOBILE ACCIDENT	29,442.0	13,776	0.195	24.97	128.23
CABLE FAULT	19,111.0	15,561	0.220	16.21	73.69
DETERIORATION, ROT, CORROSION, TERMITES	17,276.7	9,021	0.128	14.65	114.91
HIGH WIND	13,799.0	6,689	0.095	11.70	123.78
FOREIGN OBJECTS IN LINES OR EQUIPMENT	8,055.3	5,629	0.080	6.83	85.86
EQUIPMENT FAILURE	7,960.4	9,784	0.138	6.75	48.82
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	6,790.6	2,912	0.041	5.76	139.92
UNKNOWN FAILURE	4,325.4	2,329	0.033	3.67	111.43
FLASHOVER	2,371.1	4,139	0.059	2.01	34.37
LIGHTNING	2,067.6	2,425	0.034	1.75	51.16
MYLAR BALLOONS	1,801.5	3,751	0.053	1.53	28.82
MAN OR ANIMALS IN LINES OR EQUIPMENT	1,613.4	1,255	0.018	1.37	77.13
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	626.4	786	0.011	0.53	47.82
LOOSE CONNECTION	548.8	3,283	0.046	0.47	10.03
CONTACT BY MOVING EQUIPMENT	533.3	431	0.006	0.45	74.24
TRANSFORMER FAILURE OTHER THAN OVERLOAD	252.1	34	0.000	0.21	444.79
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	200.4	64	0.001	0.17	187.88
FIRE	114.0	65	0.001	0.10	105.23
TRANSFORMER OVERLOAD	96.5	19	0.000	0.08	304.58
FAILURE OF CUSTOMER'S ELECTRICAL	63.5	10	0.000	0.05	380.90
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	19.1	576	0.008	0.02	1.99
EQUIPMENT OVERLOAD	8.5	15	0.000	0.01	34.00
EXCAVATION AND CONSTRUCTION	5.8	3	0.000	0.00	115.00
OTHER COMPANY PERSONNEL ERROR	5.6	3	0.000	0.00	112.00
SYSTEM ADDITIONS OR REMOVALS	3.7	1	0.000	0.00	224.00
OPERATOR OR SWITCHING ERROR	0.7	18	0.000	0.00	2.22
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
TOTAL	181,935.4	115,289	1.630	154.30	94.68

AVERAGE SYSTEM AVAILABILITY = 99.9706%
NUMBER OF CUSTOMERS FOR THE PERIOD = 70,745
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2015 - 12/31/2016 = 152.71
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2015 - 12/31/2016 = 70,524
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

Maui Electric Company **Normalized Sustained Interruption Summary – Maui**

FROM: JANUARY 1, 2016

TO: DECEMBER 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
TREES OR BRANCHES IN LINES	56,017.4	28,816	0.438	51.08	116.64
AUTOMOBILE ACCIDENT	27,675.6	13,362	0.203	25.24	124.27
DETERIORATION, ROT, CORROSION, TERMITES	16,236.4	8,362	0.127	14.81	116.50
HIGH WIND	13,792.5	6,683	0.102	12.58	123.83
CABLE FAULT	13,351.1	13,090	0.199	12.17	61.20
EQUIPMENT FAILURE	7,949.9	9,775	0.149	7.25	48.80
FOREIGN OBJECTS IN LINES OR EQUIPMENT	7,868.8	5,484	0.083	7.18	86.09
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	5,386.6	2,709	0.041	4.91	119.30
UNKNOWN FAILURE	4,108.8	2,274	0.035	3.75	108.41
FLASHOVER	2,371.1	4,139	0.063	2.16	34.37
LIGHTNING	1,925.4	1,656	0.025	1.76	69.76
MYLAR BALLOON	1,801.5	3,751	0.057	1.64	28.82
MAN OR ANIMALS IN LINES OR EQUIPMENT	879.6	600	0.009	0.80	87.96
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	626.4	786	0.012	0.57	47.82
LOOSE CONNECTION	548.8	3,283	0.050	0.50	10.03
TRANSFORMER FAILURE OTHER THAN OVERLOAD	252.1	34	0.001	0.23	444.79
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	200.4	64	0.001	0.18	187.88
FIRE	114.0	65	0.001	0.10	105.23
TRANSFORMER OVERLOAD	96.5	19	0.000	0.09	304.58
FAILURE OF CUSTOMER'S ELECTRICAL	63.5	10	0.000	0.06	380.90
CONTACT BY MOVING EQUIPMENT	22.7	17	0.000	0.02	80.12
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	19.1	576	0.009	0.02	1.99
EQUIPMENT OVERLOAD	8.5	15	0.000	0.01	34.00
EXCAVATION AND CONSTRUCTION	5.8	3	0.000	0.01	115.00
OTHER COMPANY PERSONNEL ERROR	5.6	3	0.000	0.01	112.00
SYSTEM ADDITIONS OR REMOVALS	3.7	1	0.000	0.00	224.00
OPERATOR OR SWITCHING ERROR	0.7	18	0.000	0.00	2.22
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
TOTAL	161,332.1	105,595	1.605	147.11	91.67

AVERAGE SYSTEM AVAILABILITY = 99.9720%
NUMBER OF CUSTOMERS FOR THE PERIOD = 65,799
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 121.21
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 65,595
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

Maui Electric Company
Normalized Sustained Interruption Summary – Molokai

FROM: JANUARY 1, 2016

TO: DECEMBER 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
TREES OR BRANCHES IN LINES	8,810.4	3,881	1.208	164.58	136.21
CABLE FAULT	5,759.9	2,471	0.769	107.60	139.86
AUTOMOBILE ACCIDENT	1,766.4	414	0.129	33.00	256.00
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	1,128.0	120	0.037	21.07	564.00
DETERIORATION, ROT, CORROSION, TERMITES	1,035.4	657	0.205	19.34	94.56
MAN OR ANIMALS IN LINES OR EQUIPMENT	726.0	639	0.199	13.56	68.17
CONTACT BY MOVING EQUIPMENT	510.6	414	0.129	9.54	74.00
UNKNOWN FAILURE	207.9	42	0.013	3.88	297.00
FOREIGN OBJECTS IN LINES OR EQUIPMENT	186.5	145	0.045	3.48	77.16
FIRE	0.0	0	0.000	0.00	0.00
EXCAVATION AND CONSTRUCTION	0.0	0	0.000	0.00	0.00
LIGHTNING	0.0	0	0.000	0.00	0.00
HIGH WIND	0.0	0	0.000	0.00	0.00
LOOSE CONNECTION	0.0	0	0.000	0.00	0.00
FLASHOVER	0.0	0	0.000	0.00	0.00
TRANSFORMER FAILURE OTHER THAN OVERLOAD	0.0	0	0.000	0.00	0.00
TRANSFORMER OVERLOAD	0.0	0	0.000	0.00	0.00
EQUIPMENT OVERLOAD	0.0	0	0.000	0.00	0.00
EQUIPMENT FAILURE	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
OPERATOR OR SWITCHING ERROR	0.0	0	0.000	0.00	0.00
FAILURE OF CUSTOMER'S ELECTRICAL	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0.0	0	0.000	0.00	0.00
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	0.0	0	0.000	0.00	0.00
SYSTEM ADDITIONS OR REMOVALS	0.0	0	0.000	0.00	0.00
OTHER COMPANY PERSONNEL ERROR	0.0	0	0.000	0.00	0.00
MYLAR BALLOON	0.0	0	0.000	0.00	0.00
TOTAL	20,131.1	8,783	2.734	376.05	137.52

AVERAGE SYSTEM AVAILABILITY = 99.9285%
NUMBER OF CUSTOMERS FOR THE PERIOD = 3,212
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 290.46
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 3,203
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

Maui Electric Company **Normalized Sustained Interruption Summary – Lanai**

FROM: JANUARY 1, 2016

TO: DECEMBER 31, 2016

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	276.0	83	0.048	9.56	199.53
LIGHTNING	142.2	769	0.444	4.92	11.10
TREES OR BRANCHES IN LINES	15.6	13	0.008	0.54	72.00
EQUIPMENT FAILURE	10.5	9	0.005	0.36	70.00
UNKNOWN FAILURE	8.7	13	0.008	0.30	40.23
MAN OR ANIMALS IN LINES OR EQUIPMENT	7.8	16	0.009	0.27	29.13
HIGH WIND	6.5	6	0.003	0.23	65.00
DETERIORATION, ROT, CORROSION, TERMITES	4.9	2	0.001	0.17	147.00
AUTOMOBILE ACCIDENT	0.0	0	0.000	0.00	0.00
FOREIGN OBJECTS IN LINES OR EQUIPMENT	0.0	0	0.000	0.00	0.00
FIRE	0.0	0	0.000	0.00	0.00
CONTACT BY MOVING EQUIPMENT	0.0	0	0.000	0.00	0.00
EXCAVATION AND CONSTRUCTION	0.0	0	0.000	0.00	0.00
LOOSE CONNECTION	0.0	0	0.000	0.00	0.00
FLASHOVER	0.0	0	0.000	0.00	0.00
CABLE FAULT	0.0	0	0.000	0.00	0.00
TRANSFORMER FAILURE OTHER THAN OVERLOAD	0.0	0	0.000	0.00	0.00
TRANSFORMER OVERLOAD	0.0	0	0.000	0.00	0.00
EQUIPMENT OVERLOAD	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
OPERATOR OR SWITCHING ERROR	0.0	0	0.000	0.00	0.00
FAILURE OF CUSTOMER'S ELECTRICAL	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0.0	0	0.000	0.00	0.00
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	0.0	0	0.000	0.00	0.00
SYSTEM ADDITIONS OR REMOVALS	0.0	0	0.000	0.00	0.00
OTHER COMPANY PERSONNEL ERROR	0.0	0	0.000	0.00	0.00
MYLAR BALLOON	0.0	0	0.000	0.00	0.00
TOTAL	472.2	911	0.526	16.35	31.10

AVERAGE SYSTEM AVAILABILITY = 99.9969%
 NUMBER OF CUSTOMERS FOR THE PERIOD = 1,733
 24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 17.30
 24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 1,727
 SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX
 SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)
 CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.
 OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

Maui Electric Company
Normalized Sustained Interruption Summary – System Total

FROM: JANUARY 1, 2016 **TO:** DECEMBER 31, 2016

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	230	29.91%	106471.9	58.5%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	7	0.91%	8055.3	4.4%
CONTACT BY MOVING EQUIPMENT	4	0.52%	533.3	0.3%
EXCAVATION AND CONSTRUCTION	1	0.13%	5.8	0.0%
FIRE	2	0.26%	114.0	0.1%
AUTOMOBILE ACCIDENT	20	2.60%	29442.0	16.2%
MAN OR ANIMAL IN LINES	12	1.56%	1613.4	0.9%
TREES OR BRANCHES IN LINES	177	23.02%	64843.4	35.6%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	4	0.52%	63.5	0.0%
MYLAR BALLOONS	3	0.39%	1801.5	1.0%
<u>ERROR</u>	4	0.52%	6.3	0.0%
OPERATOR OR SWITCHING ERROR	3	0.39%	0.7	0.0%
OTHER COMPANY PERSONNEL ERROR	1	0.13%	5.6	0.0%
<u>WEATHER</u>	41	5.33%	15866.6	8.7%
LIGHTNING	17	2.21%	2067.6	1.1%
HIGH WIND	24	3.12%	13799.0	7.6%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	174	22.63%	47276.5	26.0%
LOOSE CONNECTION	11	1.43%	548.8	0.3%
FLASHOVER	3	0.39%	2371.1	1.3%
EQUIPMENT FAILURE	13	1.69%	7960.4	4.4%
CABLE FAULT	59	7.67%	19111.0	10.5%
EQUIPMENT OVERLOAD	1	0.13%	8.5	0.0%
DETERIORATION, CORROSION OR TERMITES	87	11.31%	17276.7	9.5%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	15	1.95%	348.5	0.2%
TRANSFORMER OVERLOAD	2	0.26%	96.5	0.1%
TRANSFORMER FAILURE	13	1.69%	252.1	0.1%
<u>SWITCHING</u>	5	0.65%	219.5	0.1%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	2	0.26%	19.1	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	3	0.39%	200.4	0.1%
<u>UNKNOWN</u>	30	3.90%	4325.4	2.4%
<u>MAINTENANCE</u>	269	34.98%	7417.0	4.1%
SCHEDULED ON EXISTING SERVICE	237	30.82%	6790.6	3.7%
UNSCHEDULED ON EXISTING SERVICE	32	4.16%	626.4	0.3%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	1	0.13%	3.7	0.0%
<u>TOTALS</u>	769		181935.4	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

Maui Electric Company **Normalized Sustained Interruption Summary – Maui**

FROM: JANUARY 1, 2016 **TO:** DECEMBER 31, 2016

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	207	29.78%	94448.7	58.5%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	5	0.72%	7868.8	4.9%
CONTACT BY MOVING EQUIPMENT	3	0.43%	22.7	0.0%
EXCAVATION AND CONSTRUCTION	1	0.14%	5.8	0.0%
FIRE	2	0.29%	114.0	0.1%
AUTOMOBILE ACCIDENT	19	2.73%	27675.6	17.2%
MAN OR ANIMAL IN LINES	6	0.86%	879.6	0.5%
TREES OR BRANCHES IN LINES	164	23.60%	56017.4	34.7%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	4	0.58%	63.5	0.0%
MYLAR BALLOONS	3	0.43%	1801.5	1.1%
<u>ERROR</u>	4	0.58%	6.3	0.0%
OPERATOR OR SWITCHING ERROR	3	0.43%	0.7	0.0%
OTHER COMPANY PERSONNEL ERROR	1	0.14%	5.6	0.0%
<u>WEATHER</u>	38	5.47%	15717.9	9.7%
LIGHTNING	15	2.16%	1925.4	1.2%
HIGH WIND	23	3.31%	13792.5	8.5%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	158	22.73%	40465.8	25.1%
LOOSE CONNECTION	11	1.58%	548.8	0.3%
FLASHOVER	3	0.43%	2371.1	1.5%
EQUIPMENT FAILURE	12	1.73%	7949.9	4.9%
CABLE FAULT	49	7.05%	13351.1	8.3%
EQUIPMENT OVERLOAD	1	0.14%	8.5	0.0%
DETERIORATION, CORROSION OR TERMITES	82	11.80%	16236.4	10.1%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	15	2.16%	348.5	0.2%
TRANSFORMER OVERLOAD	2	0.29%	96.5	0.1%
TRANSFORMER FAILURE	13	1.87%	252.1	0.2%
<u>SWITCHING</u>	5	0.72%	219.5	0.1%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	2	0.29%	19.1	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	3	0.43%	200.4	0.1%
<u>UNKNOWN</u>	26	3.74%	4108.8	2.5%
<u>MAINTENANCE</u>	241	34.68%	6013.0	3.7%
SCHEDULED ON EXISTING SERVICE	209	30.07%	5386.6	3.3%
UNSCHEDULED ON EXISTING SERVICE	32	4.60%	626.4	0.4%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	1	0.14%	3.7	0.0%
<u>TOTALS</u>	695		161332.1	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

Maui Electric Company
Normalized Sustained Interruption Summary – Molokai

FROM: JANUARY 1, 2016 **TO:** DECEMBER 31, 2016

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	20	57.14%	11999.9	59.6%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	2	5.71%	186.5	0.9%
CONTACT BY MOVING EQUIPMENT	1	2.86%	510.6	2.5%
EXCAVATION AND CONSTRUCTION	0	0.00%	0.0	0.0%
FIRE	0	0.00%	0.0	0.0%
AUTOMOBILE ACCIDENT	1	2.86%	1766.4	8.8%
MAN OR ANIMAL IN LINES	4	11.43%	726.0	3.6%
TREES OR BRANCHES IN LINES	12	34.29%	8810.4	43.8%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	0	0.00%	0.0	0.0%
MYLAR BALLOONS	0	0.00%	0.0	0.0%
<u>ERROR</u>	0	0.00%	0.0	0.0%
OPERATOR OR SWITCHING ERROR	0	0.00%	0.0	0.0%
OTHER COMPANY PERSONNEL ERROR	0	0.00%	0.0	0.0%
<u>WEATHER</u>	0	0.00%	0.0	0.0%
LIGHTNING	0	0.00%	0.0	0.0%
HIGH WIND	0	0.00%	0.0	0.0%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	13	37.14%	6795.3	33.8%
LOOSE CONNECTION	0	0.00%	0.0	0.0%
FLASHOVER	0	0.00%	0.0	0.0%
EQUIPMENT FAILURE	0	0.00%	0.0	0.0%
CABLE FAULT	10	28.57%	5759.9	28.6%
EQUIPMENT OVERLOAD	0	0.00%	0.0	0.0%
DETERIORATION, CORROSION OR TERMITES	3	8.57%	1035.4	5.1%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	0	0.00%	0.0	0.0%
TRANSFORMER OVERLOAD	0	0.00%	0.0	0.0%
TRANSFORMER FAILURE	0	0.00%	0.0	0.0%
<u>SWITCHING</u>	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0	0.00%	0.0	0.0%
<u>UNKNOWN</u>	1	2.86%	207.9	1.0%
<u>MAINTENANCE</u>	1	2.86%	1128.0	5.6%
SCHEDULED ON EXISTING SERVICE	1	2.86%	1128.0	5.6%
UNSCHEDULED ON EXISTING SERVICE	0	0.00%	0.0	0.0%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	0	0.00%	0.0	0.0%
<u>TOTALS</u>	35		20131.1	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

Maui Electric Company
Normalized Sustained Interruption Summary – Lanai

FROM: JANUARY 1, 2016 **TO:** DECEMBER 31, 2016

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	3	7.69%	23.4	4.9%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	0	0.00%	0.0	0.0%
CONTACT BY MOVING EQUIPMENT	0	0.00%	0.0	0.0%
EXCAVATION AND CONSTRUCTION	0	0.00%	0.0	0.0%
FIRE	0	0.00%	0.0	0.0%
AUTOMOBILE ACCIDENT	0	0.00%	0.0	0.0%
MAN OR ANIMAL IN LINES	2	5.13%	7.8	1.6%
TREES OR BRANCHES IN LINES	1	2.56%	15.6	3.3%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	0	0.00%	0.0	0.0%
MYLAR BALLOONS	0	0.00%	0.0	0.0%
<u>ERROR</u>	0	0.00%	0.0	0.0%
OPERATOR OR SWITCHING ERROR	0	0.00%	0.0	0.0%
OTHER COMPANY PERSONNEL ERROR	0	0.00%	0.0	0.0%
<u>WEATHER</u>	3	7.69%	148.7	31.5%
LIGHTNING	2	5.13%	142.2	30.1%
HIGH WIND	1	2.56%	6.5	1.4%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	3	7.69%	15.4	3.3%
LOOSE CONNECTION	0	0.00%	0.0	0.0%
FLASHOVER	0	0.00%	0.0	0.0%
EQUIPMENT FAILURE	1	2.56%	10.5	2.2%
CABLE FAULT	0	0.00%	0.0	0.0%
EQUIPMENT OVERLOAD	0	0.00%	0.0	0.0%
DETERIORATION, CORROSION OR TERMITES	2	5.13%	4.9	1.0%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	0	0.00%	0.0	0.0%
TRANSFORMER OVERLOAD	0	0.00%	0.0	0.0%
TRANSFORMER FAILURE	0	0.00%	0.0	0.0%
<u>SWITCHING</u>	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0	0.00%	0.0	0.0%
<u>UNKNOWN</u>	3	7.69%	8.7	1.8%
<u>MAINTENANCE</u>	27	69.23%	276.0	58.5%
SCHEDULED ON EXISTING SERVICE	27	69.23%	276.0	58.5%
UNSCHEDULED ON EXISTING SERVICE	0	0.00%	0.0	0.0%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	0	0.00%	0.0	0.0%
<u>TOTALS</u>	39		472.2	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

DEFINITION OF TERMS

OUTAGE

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

INTERRUPTION

The loss of service to one or more consumers and is a result of one or more component outages.

INTERRUPTION DURATION

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

MOMENTARY INTERRUPTION

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HECO Utilities" indicated that momentary interruptions will have duration of less than one minute.

SUSTAINED INTERRUPTION

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990, a sustained interruption has duration of one minute or longer.

CUSTOMER INTERRUPTION

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., customer maintenance) are not considered.

Attachment-C

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Five reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

RELIABILITY INDICES

AVERAGE SERVICE AVAILABILITY INDEX (ASA)

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$